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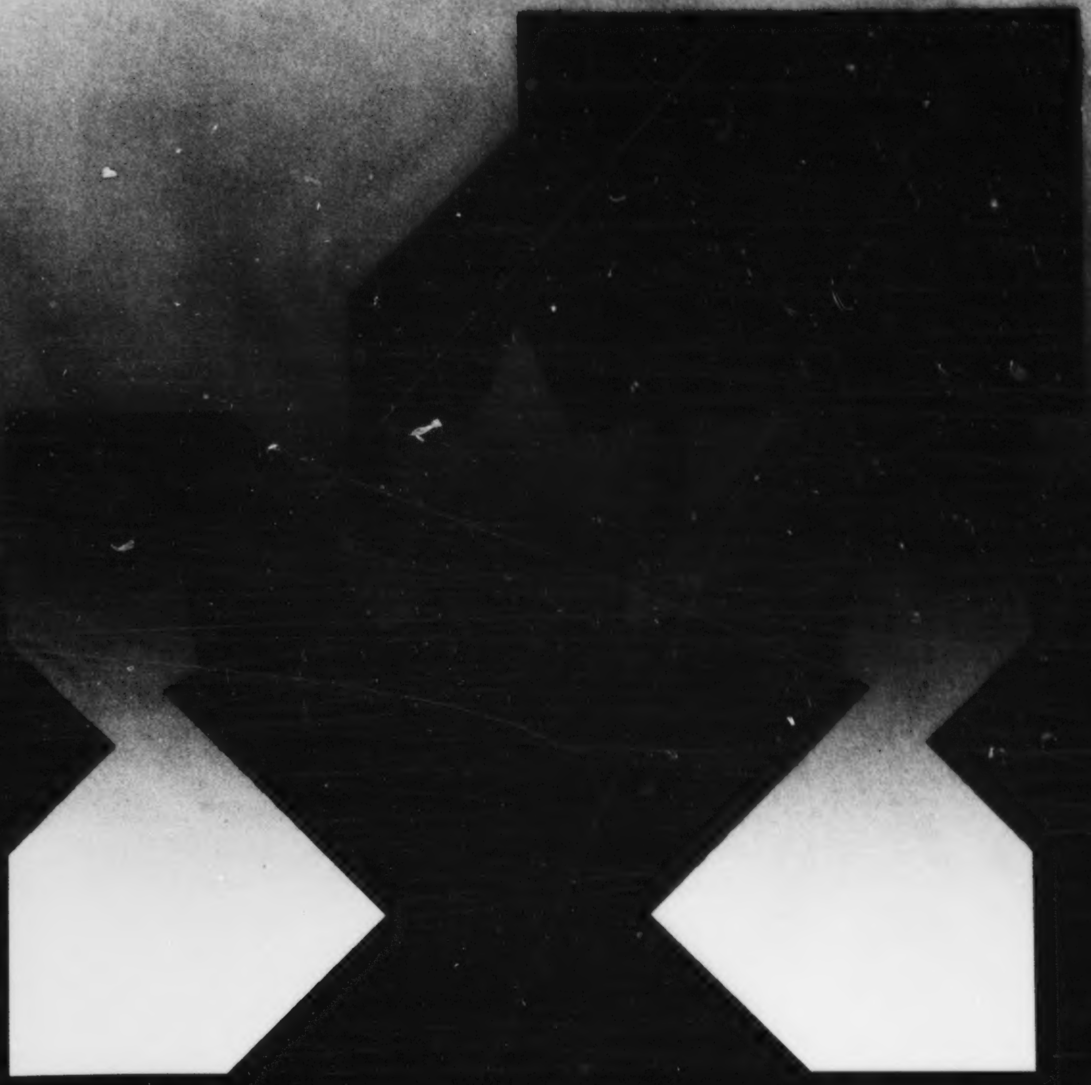

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ADVANCED PLANNING AND CONTROL TECHNOLOGIES FOR HOUSING CONSTRUCTION

ADVANCED PLANNING AND CONTROL TECHNOLOGIES FOR HOUSING CONSTRUCTION

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The views expressed are those of the author and do not represent the official views of the Corporation.

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The detailed case studies would not have been possible without other financial support and the cooperation of a young, forward thinking, non-union construction firm in Vancouver, B.C. This firm has requested anonymity.

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I would like to thank JS, JM, BJ and RS of the Vancouver firm for their cooperation and willingness to share their knowledge with the research group. Their extended commitment to the research effort is not typical of most firms and reflects the view of the president, JS, that the future of construction will be different than the past.

Members of the research team included three students, Henry Tse, John Wong and Roger Tse; Neill McGowan, a research engineer; three computer programmers, William Wong, John Chow and Jeff Nishimura; and myself.

Finally, my thanks to Sylvia Dodd for her assistance in casting this report in a presentable form.

ABSTRACT

Topics treated in this report deal with:

1) Detailed case studies of two projects,
2) Approaches to schedule updating with emphasis on the collection of field performance information, and
3) Useful ways for representing project experience in order to create a knowledge base for the eventual development of an expert system for activity scoping and sequencing.

The context of this work is high-rise, residential construction.

The findings of the report are of use to general contractors, construction managers, developer-builders and individuals or groups seeking to develop improved management tools for the construction industry.

Two detailed case studies are presented to demonstrate the current state of time management practices in the construction industry, to explore the use of different updating formats and to demonstrate the power of repetitive planning structures, especially for speedy updating when location sequences change.

In the treatment of schedule updating, emphasis is placed on the problem of collecting accurate field data which can be quickly incorporated into the schedule. Impediments to this process and more holistic and long term solutions, such as automated daily site reporting and analysis, are explored, as well.

Work on the third topic focused on identifying frameworks for standardizing and representing project experience, and describing it in the form of rules that can be incorporated into an expert system. Attention is directed to activity scoping and sequencing. One of the main findings of the case studies was that projects are poorly scoped, especially in terms of subtrade work. The level of detail typically employed is insufficient to identify coordination interfaces and to pinpoint problem sources and solutions.

EXECUTIVE SUMMARY

REPORT OBJECTIVES AND CONTRIBUTIONS

The research objectives adopted throughout the tenure of this research project were threefold:

1) To explore the use of advanced planning technologies and computer graphics for defining and evaluating alternative construction plans through the mechanism of case studies;

2) To develop a process for updating which accounts for changes in activity sequencing, activity durations, delays and acceleration of work and scope changes, and for evaluating and selecting appropriate corrective action; and

3) To examine useful ways for representing project experience in order to create a knowledge base for the development of an expert system.

The application domain for the research work was multi-storey residential construction, with the overall goal being to generate improved processes and tools for time management of the construction phase.

SUMMARY OF ACCOMPLISHMENTS

The linear planning or time-space diagram (9)(18) provided the focus for the first objective. Use of the diagram as an analysis tool for selecting and evaluating more complex construction strategies as described by activity and work location sequencing, crewing, continuity constraints and scheduled work interruptions was studied through its application to actual projects. Documentation of the lessons learned from this use of the planning tool is viewed as one of the main contributions of this report. These lessons have been incorporated in the report sections dealing with updating and representing project experience.

The linear planning representation was shown to be a very practical analysis tool, both for planning and for assessing the effectiveness with which the project is being executed. It was less useful as a field information format because of its perceived complexity by field personnel as compared to the traditional bar chart and because of the difficulty in maintaining clarity and readability when several activities are scheduled simultaneously and/or all activities are shown.

To meet the second objective, the dimensions of the updating problem were examined in detail. Elements treated included the evolving nature of the definition of a project, constantly changing activity and location sequences, the difficulty in obtaining accurate feedback from the field, the need for easy and simple to use field data collection formats, mechanisms for the speedy incorporation of actual performance data into the schedule and ways to allow quick revision of the plan and schedule, including actions taken to expedite work yet to be done because of performance to date or because of changing project conditions - e.g. sales of units, changes in finishing schedules, etc. The usefulness of repetitive activity planning structures to simplify the updating task, especially in regard to changing activity and work location sequences was demonstrated. The potential for automated daily site reporting to provide a framework for updating while satisfying other reporting needs is explored.

In relation to the third objective, emphasis was placed on frameworks for standardizing and representing project experience, and describing experience in the form of rules that can be incorporated into an expert system. The specific focus was on the accurate scoping of work in terms of construction activities and the sequencing of activities. One of the main findings of the study was that projects are poorly scoped, especially for subtrade work. The level of detail typically employed is insufficient to identify coordination interfaces and precludes the use of integrated management systems which depend on the activity as a cost and time centre for the functions of planning and control, progress billing, procurement, change order management, and cash flow management.

REPORT AUDIENCE

The findings in this report are directed primarily at general contracting firms which specialize in the construction of multi-storey residential projects. They are equally applicable to small and large contracting firms and are also relevant to those firms which offer professional construction management services as well as to developer-owners who play an activist or lead role in the construction phase.

The report should be of special interest to developer-owners because it demonstrates the time penalties associated with inadequate planning and control practices and untimely decision-making or intervention on the part of the owner. The owner is the main beneficiary of well planned and controlled construction projects. Yet, they often are too tolerant of less than professional management practices on the part of the contractor, accepting too easily the contractor's thesis that construction is complex and unpredictable. In many cases, they have failed to inform themselves of the state-of-the-art of construction project management techniques and systems and consequently have not been demanding enough through contractual mechanisms for a professional approach or have not enforced contractual provisions when they have been specified.

They most often are short-sighted in terms of a preoccupation with a construction cost bottom line approach. They reward the contractor who strips out management resources in order to have the lowest price. Consequently projects are inadequately planned and controlled, resulting in total costs (construction costs + land costs + interest during construction) not being minimized because of schedule delays. This aspect is made worse by poor cash flow planning (accurate forecasts of billings) because expenditures are not accurately predicted, resulting in lost opportunities for short term investing of funds, both on the part of the contractor and the owner. Additional cost penalties due to schedule delays arise from missed market opportunities, as other competing projects come on line.

The findings should also be of interest to other researchers engaged in the search for improved management tools for the construction industry, and who require insights on prevailing practices and constraints.

The work described in this report constitutes a small part of an ongoing research project under the author's supervision which has been supported by a number of research agencies as well as private sector firms. The overall goal of this project is directed at formulating improved tools for all of the main construction project management functions: planning and scheduling, procurement, subcontract control, cash management, change orders, activity design, detailed short cycle planning and client reporting. The focus of the CMHC funded work, as described in the report objectives is on the planning and scheduling and field updating aspect.

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References

CHAPTER 1: INTRODUCTION

1.1 REPORT OBJECTIVES AND CONTRIBUTIONS

The research objectives adopted throughout the tenure of this research project were threefold:

1) To explore the use of advanced planning technologies and computer graphics for defining and evaluating alternative construction plans through the mechanism of case studies;

2) To develop a process for updating which accounts for changes in activity sequencing, activity durations, delays and acceleration of work and scope changes, and for evaluating and selecting appropriate corrective action; and

3) To examine useful ways for representing project experience in order to create a knowledge base for the development of an expert system.

The application domain for the research work was multi-storey residential construction, with the overall goal being to generate improved processes and tools for time management of the construction phase.

1.2 SUMMARY OF ACCOMPLISHMENTS

The linear planning or time-space diagram (9)(18) provided the focus for the first objective. Use of the diagram as an analysis tool for selecting and evaluating more complex construction strategies as described by activity and work location sequencing, crewing, continuity constraints and scheduled work interruptions was studied through its application to actual projects. Documentation of the lessons learned from this use of the planning tool is viewed as one of the main contributions of this report. These lessons have been incorporated in the report sections dealing with updating and representing project experience.

The linear planning representation was shown to be a very practical analysis tool, both for planning and for assessing the effectiveness with which the project is being executed. It was less useful as a field information format because of its perceived complexity by field personnel as compared to the traditional bar chart and because of the difficulty in maintaining clarity and readability when several activities are scheduled simultaneously and/or all activities are shown.

To meet the second objective, the dimensions of the updating problem were examined in detail. Elements treated included the evolving nature of the definition of a project, constantly changing activity and location sequences, the difficulty in obtaining accurate feedback from the field, the need for easy and simple to use field data collection formats, mechanisms for the speedy incorporation of actual performance data into the schedule and ways to allow quick revision of the plan and schedule, including actions taken to expedite work yet to be done because of performance to date or because of changing project conditions - e.g. sales of units, changes in finishing schedules, etc. The usefulness of repetitive activity planning structures to simplify the updating task, especially in regard to changing activity and work location sequences was demonstrated. The potential for automated daily site reporting to provide a framework for updating while satisfying other reporting needs is explored.

In relation to the third objective, emphasis was placed on frameworks for standardizing and representing project experience, and describing experience in the form of rules that can be incorporated into an expert system. The specific focus was on the accurate scoping of work in terms of construction activities and the sequencing of activities. One of the main findings of the study was that projects are poorly scoped, especially for subtrade work. The level of detail typically employed is insufficient to identify coordination interfaces and precludes the use of integrated management systems which depend on the activity as a cost and time centre for the functions of planning and control, progress billing, procurement, change order management, and cash flow management.

1.3 REPORT AUDIENCE

The findings in this report are directed primarily at general contracting firms which specialize in the construction of multi-storey residential projects. They are equally applicable to small and large contracting firms and are also relevant to those firms which offer professional construction management services as well as to developer-owners who play an activist or lead role in the construction phase.

The report should be of special interest to developer-owners because it demonstrates the time penalties associated with inadequate planning and control practices and untimely decision-making or intervention on the part of the owner. The owner is the main beneficiary of well planned and controlled construction projects. Yet, they often are too tolerant of less than professional management practices on the part of the contractor, accepting too easily the contractor's thesis that construction is complex and unpredictable. In many cases, they have failed to inform themselves of the state-of-the-art of construction project management techniques and systems and consequently have not been demanding enough through contractual mechanisms for a professional approach or have not enforced contractual provisions when they have been specified.

They most often are short-sighted in terms of a preoccupation with a construction cost bottom line approach. They reward the contractor who strips out management resources in order to have the lowest price. Consequently projects are inadequately planned and controlled, resulting in total costs (construction costs + land costs + interest during construction) not being minimized because of schedule delays. This aspect is made worse by poor cash flow planning (accurate forecasts of billings) because expenditures are not accurately predicted, resulting in lost opportunities for short term investing of funds, both on the part of the contractor and the owner. Additional cost penalties due to schedule delays arise from missed market opportunities, as other competing projects come on line.

The findings should also be of interest to other researchers engaged in the search for improved management tools for the construction industry, and who require insights on prevailing practices and constraints.

The work described in this report constitutes a small part of an ongoing research project under the author's supervision which has been supported by a number of research agencies as well as private sector firms. The overall goal of this project is directed at formulating improved tools for all of the main construction project management functions: planning and scheduling, procurement, subcontract control, cash management, change orders, activity design, detailed short cycle planning and client reporting. The focus of the CMHC funded work, as described in the report objectives is on the planning and scheduling and field updating aspect.

1.4 AN ASSESSMENT OF CURRENT PRACTICES AND PROBLEMS

The paradigm for the planning and control process is conceptually simple:

1) scope the work, based on project definition and past experience;
2) sequence the work;
3) select methods for the activities and hence the durations or production rates;
4) compute the schedule;
5) iterate with those involved to ensure acceptability;
6) communicate and implement the plan;
7) monitor progress;
8) incorporate actual performance in the plan and revise, as required; and once completed, barring claims, and
9) document the experience in a form useful for future projects.

For virtually every step in this process, there are difficulties. To carry out the first three steps well requires that the ninth step has been performed for previous projects. Invariably, however, past experience is poorly documented, if at all. It resides in the heads of key project personnel, and their memories are incomplete or not available if they have left the firm. Consequently, the definition of a project in terms of activities (scoping) tends to be done at too aggregated a level and is incomplete. For example, subtrade work is often represented as a single activity in a bar chart (e.g. mechanical work) and important activities such as permits and approvals are often omitted. This problem is exacerbated by the fast-track nature of most residential projects.

Making matters worse, architectural and engineering drawings and specifications are incomplete and inaccurate. Reasons include the fast-track nature of this kind of work and the pervasive owner bottom-line mentality which results in professionals "bidding" for work at a price which precludes sufficient attention to details to ensure constructability. Consequently, details are worked out on site instead of being worked out on the drawing board. Penalties associated with this approach include schedule delays, and adversarial work environment and claims for extras.

Also, because the general contractor has subcontracted out so much work over the years, knowledge of coordination interfaces, work scope of subtrades and feasible production rates, is shaky, at best.

For the fourth step, usually a manual schedule is developed. In general, the level of detail is too aggregated to provide much guidance to field management as to what work should be ongoing and where at any point in time. If an attempt is made to portray this level of detail, the effort to maintain it as sequences change is viewed as not being worth the effort, resulting in no global schedule being maintained. At best, rolling one or two week schedules for selected aspects of the work are formulated to help run the project, but overall delays are not detected.

For the fifth step, insufficient attention is given to consulting with major subtrades to ensure agreement on the schedule and hence commitment to it. When they are consulted, many are unable to give a meaningful response as they have difficulty reading and comprehending even the most rudimentary schedule. Some are wary or hostile to requests for information, suspecting that it is a ruse by the contractor to extract information that can be used against them at some later date. The subtrade problem is compounded by the fact that all the major trades are seldom known at the outset, so the scheduling process unfolds over an extended time period.

In most cases, a reasonable effort is made to provide copies of the schedule to the major subtrades, thus carrying out the sixth step.

Step seven is very poorly done. If progress is reported by the superintendent in the daily site report at all, it is done using descriptors which may not relate to activities in the schedule and which change from day to day for the same work item. Minimal effort is made to record progress on any form of schedule on a regular basis.

The eighth step is also poorly done or omitted completely. Few notes exist on actual performance dates, on sequence and duration changes and reasons for them, etc. Further, the resources required to develop updated schedules and issue them to the subtrades are few and far between.

For most construction firms, one of the main impediments to effective execution of all nine steps is the lack of formal management training of construction personnel and a lack of commitment by senior personnel of the firm to a more professional approach to construction project management. This lack of commitment largely stems from an inability to demonstrate the magnitude of the financial and marketing benefits which flow from tightly managed projects. Further, it is perceived by some that the benefits are derived mainly by the owner, not the contractor, and that the owner is not willing to pay to receive them. Thus, the contractor believes his duty is to the firm's objective of minimizing direct costs. Pursuit of this objective does not necessarily minimize total costs (direct plus indirect) nor does it enhance the image of the firm for effective time control. As a consequence, too often preparation of a schedule is seen as a public relations exercise to placate the owner, and it is seldom followed by the contractor.

The pervasive philosophy at all levels in the firm, that the project controls the schedule, prevails over the belief that the schedule should control the project. This arises in part from the assertion by seasoned superintendents, seconded by project managers who have come up through the ranks, that the complexity and unpredictability of construction preclude meaningful planning and scheduling.

To rectify current deficiencies, attention needs to be directed to both technological and human/organizational issues. The focus in this report is on the former, as suggested by the report objectives. However, it is my view, after working with several contractors, that development of even the perfect planning and control tool will not transform the industry. The human/organizational side is the biggest impediment to improved planning and control. In this regard, training programs must receive high priority.

On the technical side, significant benefits could come from greatly improved daily site reporting which is automatically linked to the plan and schedule to provide virtually real time updating to maximize credibility of the schedule in the eyes of field personnel. A direct side benefit would be the collection and analysis of experience for use on future projects. Also, a framework for conducting post project analysis is required so that the lessons learned could be documented in electronic form. Issues treated would include performance characteristics of project team members (owner, consultants, subtrades, suppliers, individual project personnel), activity scoping and sequencing as a function of design features, and durations as a function of time of year, design, crew size, etc.

On the human/organizational side, several topics must be addressed. Owners must be educated about the benefits of requiring better planning and control. Consider the very simple case of a $10 million dollar construction cost only project that spans 18 months. Assuming uniform expenditures, 100% financing, and a 12% nominal interest rate with monthly compounding for the construction loan, the carrying charges over the construction period would be $895,000. Now a 10% delay in project duration (approximately 2 months), exclusive of any costs for extras, and foregone revenue, results in financing charges of $1,007,500. The difference of $112,500 is more than enough to pay for full time scheduling support, including hardware and software.

On the part of the contractor, considerable effort needs to be made to train project staff in management techniques and tools for planning and control. Project management staff are generally well versed in the practicalities of construction and in most cases pursue a problem solving approach. They are more comfortable solving technical problems (constructability issues) than management ones. Their knowledge of subtrade work could be strengthened, especially in regard to the interfacing of such work.

The construction culture within which project management staff work suggests that a project cannot be accurately scheduled and controlled because of many external, uncontrollable and unpredictable factors. This view is held largely because staff have not "grown up" with or been trained formally in modelling of construction processes or representation of construction in the form of an analytical model. They can express the process in words, but don't have the ability, interest or resources to track it in detail.

For example, many superintendents emphasize the importance of work continuity for their own forces as well as for subtrades. But they are unable to represent the continuity problem so that they can predict when crews should start and be ensured of no interruption, unless they have experienced the same situation previously. Consequently, achievement of work continuity is basically a hit and miss affair.

Thus, training in methods of describing the construction process is essential. Such training requires reinforcement over an extended period of time in order to build a good confidence level on the part of project personnel. This training should also involve a perspective on the overall construction management process to show how information is used throughout the firm. The importance of individual roles and specifically what their role is in an integrated approach to planning and control must be highlighted.

Should new management systems be implemented, a detailed plan for implementation is essential, as is a champion (19) at a senior management level. Failure of many computer based systems can be traced directly to lack of such a plan, including insufficient resources and time assigned to training.

Some rethinking of traditional roles is also required. It is advantageous for the general contractor to provide an information service to the subtrades in order to recapture vital knowledge; ensure effective coordination; integrate the functions of planning and scheduling, procurement, progress measurement and billing, and so on; and standardize reporting. The legal implications of such a strategy need careful consideration.

1.5 RESEARCH METHODOLOGY

The research methodology followed for this study consisted of several parts. First, a working relationship was established with a small (approximately $15 million volume/year) but progressive non-union contractor in Vancouver for purposes of field testing concepts developed, and to ensure their responsiveness to the realities of construction. Over a period of two years, 4 multi-storey residential projects were treated, ranging from 7 storeys to 19 storeys.

This relationship involved us in providing plans and schedules for all 4 projects, and to a certain extent, becoming the repository of the experience base of the firm as it relates to time management. We worked with two project managers and 5 project superintendents. Projects 5 through 7 were started in March, September and October, 1988. They are not discussed herein. They are mentioned because development of their schedules represents a practical application of the third objective.

The cumulative experience gained on the first few projects was used to develop a detailed schedule prior to initiation of construction. This schedule helped in the negotiations that lead to award of the project. It also has considerable credibility with key project staff as they participated in its formulation and were able to compare its features directly with their past experience.

The commitment on the part of the contractor to work with us reflected forward thinking perspective of the president of the firm. We were exposed to the good and the bad in the industry as far as management practices are concerned, and it is a credit to the firm that they became more and more open as we worked with them. The time management practices we encountered at the outset reflected the industry at large. Interestingly, these practices evolved considerably over the two year time period of our involvement. They have gone from manual scheduling with minimal updating to full computerized scheduling with frequent updating. One of the luxuries that the research group had that project staff did not was time to analyze the experience of the firm so that it could be used on future projects.

The components of our research relationship with the firm involved us in developing plans and schedules in consultation with various project staff members. The techniques used included, in some cases, discussions with subtrades and the project owner, updatings of schedules, preparation of photographic progress essays and having a graduate student work on a part time basis as an estimator and scheduler within the firm. At times, we found ourselves more in a technology transfer and training mode than a research one. Over the duration of the study period, various ideas pertaining to the collection of site data were formulated and programmed for testing.

It should be noted that it is not practical for a contractor to interact with researchers in a parallel operation. Time and resource constraints dictate that if the contractor is going to experiment, that he does so directly. This has been our experience over the last 10 years with a number of contractors. For this study, this meant that the contractor progressively relied more and more on the plans and schedules produced by the research group and did not maintain a manual schedule. This forced us to work in a project time frame, not a research one. Also, it has substantial implications for the researchers as dispassionate observers of the process, now that they are part of it.

There is a lengthy period during which the research team has to establish its credibility with project staff regarding their knowledge of the practicalities of construction. As well, time is required to build an effective working relationship with project staff. Not everyone is eager to part with hard won knowledge or, in some cases, demonstrate that their knowledge is incomplete.

The intensity of the research approach precludes its application to several firms, which is essential if the findings are to be generalized with confidence. However, through our relationships with other contractors, for example, industry partners in another major grant, and numerous discussions with other contractors and owners, I am confident that the findings reported herein reflect the industry and project norm.

In conducting the research work that lead to this report, I was assisted by several individuals. I personally did much of the field work and scheduling. I was assisted by my research engineer, Neill McGowan, and two students, Henry Tse and John Wong during the summer of 1987. Computer programming of the various concepts developed was done by Jeff Nishimura, William Wong, and John Chow. The topic of daily site reporting formed the basis for several student projects in my graduate planning and control course and currently provides the focus of a graduate research thesis by Roger Tse. Many of the figures on daily site reporting shown in Chapter 3 were developed as part of this thesis work.

1.6 REPORT STRUCTURE

Chapter 2 contains case histories of 2 projects. The purpose is to portray current planning and control practices, the context in which projects are undertaken and how practices evolve when attempts are made to formally incorporate experience from one project into another. Also, findings from the case histories help highlight the attributes required for more responsive planning systems, features required for effective updating and areas of weakness in the current knowledge base and practices of project personnel.

The topic of schedule updating is treated in Chapter 3. Emphasis is placed on the problem of collecting accurate field data which can be incorporated into the schedule quickly, impediments to this process and more holistic and long term solutions such as automated daily site reporting and analysis.

Chapter 4 treats, in considerable detail, issues of organizing and representing construction knowledge as it pertains to high rise construction projects. The goal is eventually to develop an expert system which can be used to assist in specifying and sequencing the activities required to construct such projects so as to leverage up management's time and to maximize the benefits to be derived from past experience.

CHAPTER 2: CASE STUDIES

2.1 INTRODUCTION AND OBJECTIVES

Two case studies of actual projects are presented in this chapter in order to provide the reader with insights regarding many of the realities of high-rise residential construction and their implications for the design, implementation and use of computer-based planning and control systems.

Specific objectives set for the case studies in the context of this report are:

1. To explore in detail the topics of activity scoping, sequencing and schedule updating as they relate both to current and future practice, including identification of barriers to improvement;
2. To define and test data collection formats for field progress and the use of special planning structures to ease the updating task, especially in regard to activity and location sequence changes; and
3. To examine the potential for transferring experience from one project to another.

The chapter is structured as follows. In section 2.2, we set out our methodology plus background information relating to the time frame during which the case studies were conducted. Then, in sections 2.3 and 2.4 we present two case studies in the form of an abbreviated diary, accompanied by selected schedule documents. In section 2.5 a summary of findings is made. This summary augments the one presented in section 1.4 of Chapter 1. We end in section 2.6 with a brief snapshot of what has transpired with the firm responsible for the case study projects since their completion.

2.2 CASE STUDY METHODOLOGY & BACKGROUND INFORMATION

Contact with a non-union construction firm was made in January 1986. This firm was just starting on its first high-rise residential project, a 12 story luxury condominium. It had previously completed several low-rise, wood frame projects. The president, a professional engineer, had previous experience with high-rise construction, as did the superintendent assigned to the project.

At our first meeting, which was arranged by the project architect, the objectives of the research program were described, along with our previous experience with high-rise residential construction. The president of the firm agreed to participate. We arranged for our research group to perform computerized planning and scheduling of the condominium project, in exchange for access to project and management personnel and a serious effort on the part of the firm to explore the use of computerized scheduling, especially updating. At that time (1986), all scheduling was done manually by the firm and they had no microcomputers. Their accounting was performed using external computer facilities.

The methodology we attempted to pursue throughout this project and the second case study described in this chapter, consisted of the following:

1. Preparing plans and schedules,
2. Reviewing them with project and site management personnel,
3. Updating the schedule based on frequent site visits, including the testing of various updating formats,
4. Holding several meetings to discuss research issues, and
5. Photographic monitoring of the site.

While this methodology basically was followed, we found ourselves to be the sole source of any reliable schedule once the projects were underway. Further, because both projects experienced difficulties, we were often viewed as the bearers of bad news, especially by the site superintendent. Instead of meetings being held to discuss research issues, we became involved in informal meetings, including some with the owner, to discuss and resolve scheduling problems.

The intensity of our involvement in both projects varied, with the greatest intensity occurring during the rough-in and finishing phases, exclusive of external sitework finishing. Being external to the firm, we were not in a position to insist upon completion of updating formats, which one site superintendent resisted with a passion. Throughout the study period, the president was very supportive and encouraged site staff to cooperate. To their credit, all staff were generous with their knowledge, in their own way.

During the time period over which the studies were conducted, the economic climate and level of construction activity in Vancouver changed from depressed to buoyant. These conditions affected the availability of skilled manpower and equipment (cranes, manhoists, scaffolding, formwork). At the same time, economic conditions in Ontario were booming, creating supply problems for the west. The depressed market conditions in Vancouver led to very low prices being tendered for professional consulting services as well as for subtrade work. Consequently, the quality of drawings was often poor, and professionals and subtrades attempted to cut corners to save costs, including stripping out management resources and putting additional pressure on very thin site management staffs which was often only a superintendent.

Starting in the early 1980's, the strength of the non-union sector grew substantially, such that today (1989), virtually all high-rise residential construction is performed by non-union firms. This sector is not as well organized as the union one, and the capabilities of subtrades and tradesmen are highly variable. Further, during the 80's, many tradesmen left the province to seek work in Ontario, leading to shortages in manpower when the market strengthened.

In terms of cost, time and quality priorities, direct cost considerations predominate over schedule issues for the general contractor. This observation applies both to the original scope of work as well as to changes. Changes occur frequently as owners attempt to reflect current market trends in amenities. The contractor, in an attempt to minimize direct cost, will tolerate delays even though, when queried, they admit that indirect costs may be increased. The owner, when seeking changes, will down play delays, not wanting to accept requests for extensions and/or impact costs. Only when commitments to purchasers regarding occupancy dates loom in the near term does the focus shift to schedule issues. At this time, it is basically too late to initiate any meaningful corrective action. Treatment of quality tends to focus on the selection of finishing materials and the workmanship achieved with finished surfaces.

2.3 CASE STUDY ONE

2.3.1 Project Features & Context Information

Initial Schedule

Our first meeting with the firm took place on January 20, 1986 in the offices of the architect with the president of the construction firm in attendance. The project had already started at the beginning of January. Completion was scheduled as per a manual bar chart prepared by the president for 25 October 1986. This completion date was deemed optimistic by the contractor. It was changed to 18 November 1986 when the bar chart was revised in mid-February. The revised bar chart is shown in figure 2 - 1. Actual project completion was late April 1987.

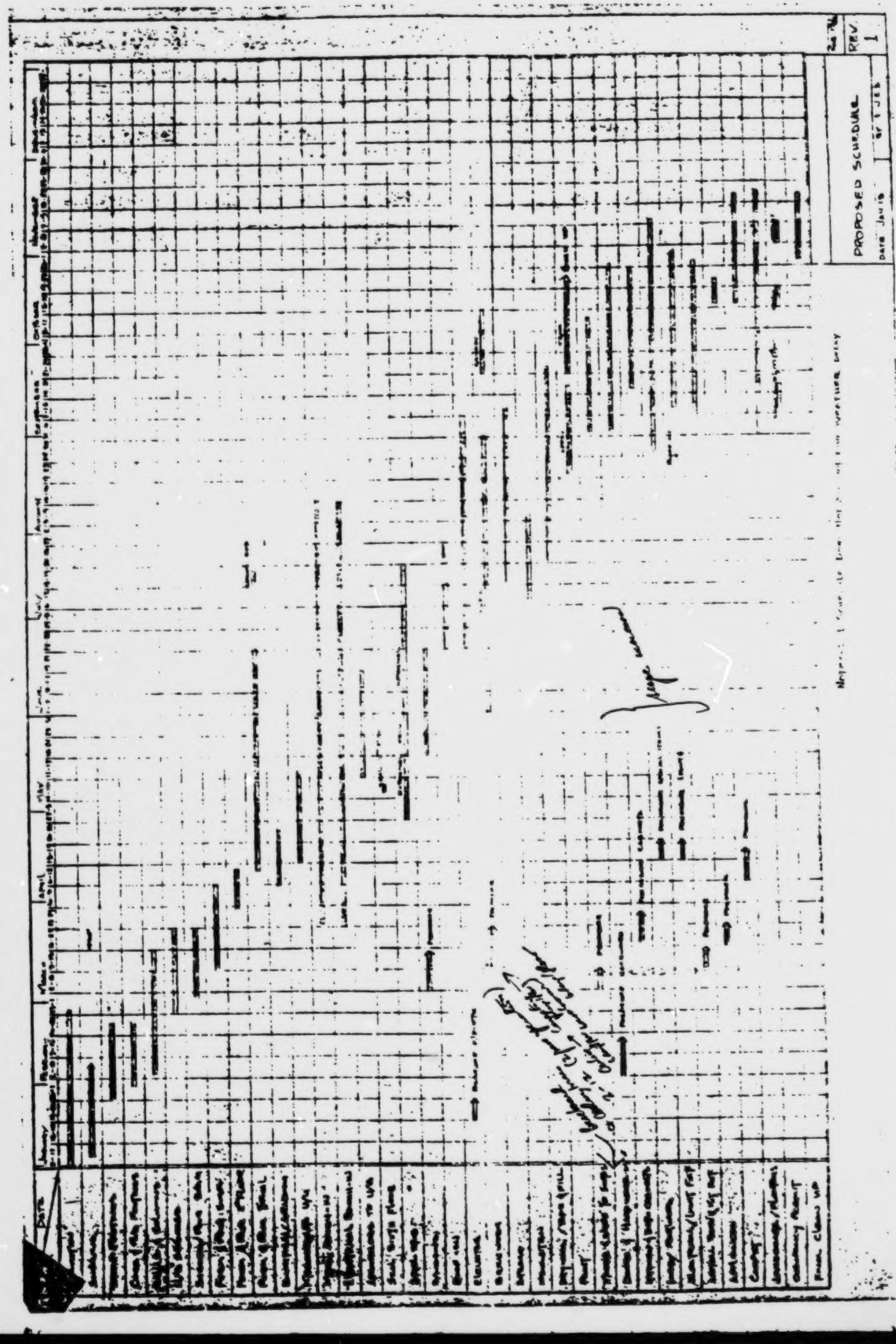


Figure 2-1 Contractor Bar Chart Schedule for Case Study One.

The contractor's bar chart schedule was not derived from a formal network representation of the project, making updating difficult. In fact, this bar chart in figure 2 - 1 was not updated by the firm. In terms of activity scoping, the level of detail adopted is quite aggregated. Further, no attempt was made to break out work on individual floors. Consequently, the schedule is of limited use for site management for treating coordination interfaces among subtrades and accurately gauging work progress. A reasonable job was done in identifying long lead time procurement items in terms of preordering.

Physical Features

The project consisted of 43 units in a 12 storey, reinforced flat plate structure, with a brick and stucco exterior. A one level substructure covered the entire site and was designed for parking and storage. Special amenities included an outdoor swimming pool and a reflecting pool on the ground floor level. No suites were located on the ground floor. The superstructure covered less than 50% of substructure. A tower crane was placed inside the superstructure. Its placement was questioned by subtrades because it occupied space where interior walls were required. Consequently, additional rough-in passes were required. A manhoist was also required.

The schedule of finishes corresponded to luxury quality and is shown in figure 2-2. Suites listed for $235000 for 1500 ft**2 to $445000 for 1760 ft**2. Penthouse units listed for over $600000.

Contractual Arrangements & Management Personnel

The firm was retained in the capacity as construction manager. The architect was retained on a lump sum contract that was underpriced by a factor of 3-4. This was a source of problems in terms of quality drawings and workable details. The president of the firm also acted as the project manager. He is referred to hereafter as JS. The job site superintendent, Bill (BJ), an old style super, is very knowledgeable of construction operations but loathes paper work. BJ was of the view that construction is almost impossible to plan and schedule except in broad terms as per the firm's original bar chart. He is not steadfast in this view, in that he believes that the use of computers will change how projects are managed. However, he asserted that he is too old to change his ways.

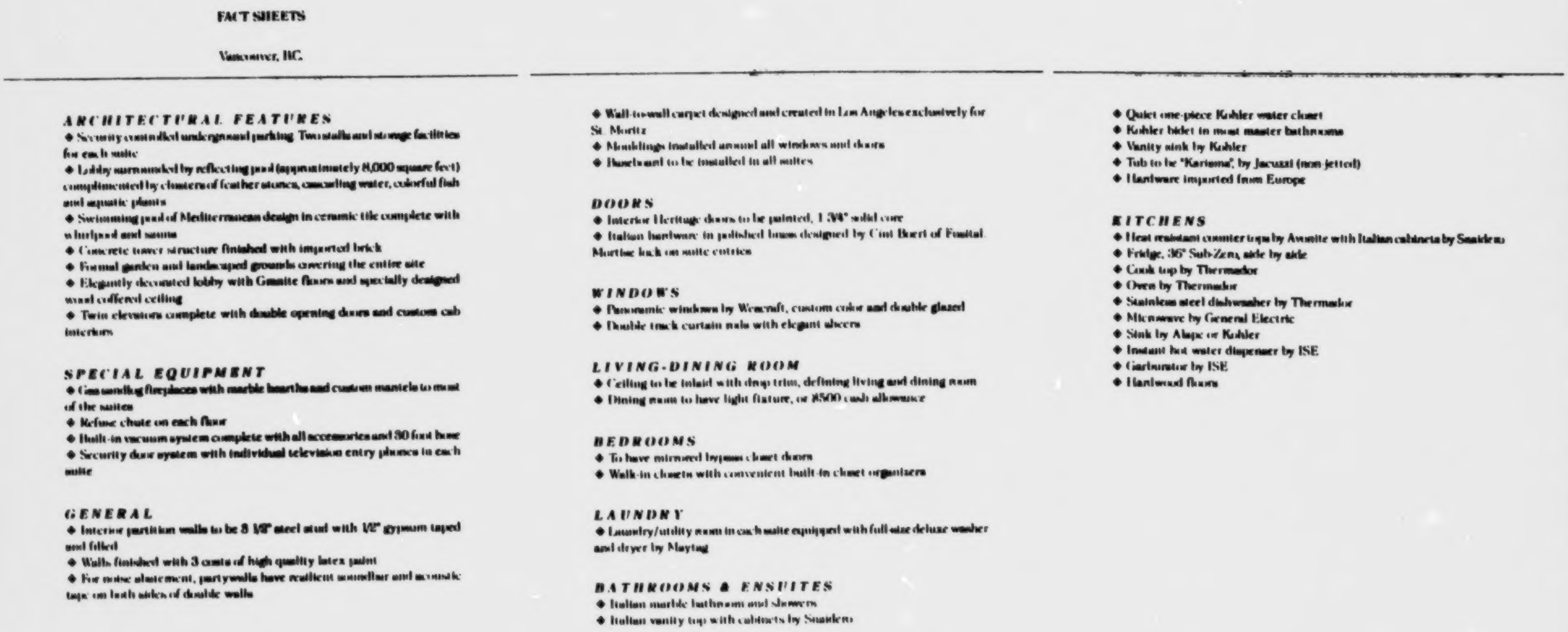
Exclusive of payroll and purchasing/rental documentation, three documents formed the basis for project control. These were:

1. the bar chart in figure 2-1,
2. the daily site report in figure 2-3 and
3. a suite finish checklist as shown in figure 2-4, which doubled as a deficiency list.

Daily site reporting was done poorly. Following this project, the firm changed to the report format shown in figure 4-5. Its detail only guaranteed further that it would not be completed.

Developer

The project developer was very interventionist by nature and attended the site almost every day. He had the reputation of building prestige projects and was also known as an extremely tough bargainer. He was a constant source of frustration as he would redirect trades, postpone or change decisions, delay procurement, request rework and so forth, making the superintendent's position difficult, if not impossible, at times. This dampened the little enthusiasm BJ had for the research, especially since we were constant bearers of bad news regarding further schedule delays. Our work was used to illustrate to the owner on numerous occasions the consequences of his decisions or lack of them.



FACT SHEETS

Vancouver, BC.

ARCHITECTURAL FEATURES

- Security controlled underground parking. Two stalls and storage facilities for each suite
- Lobby surrounded by reflecting pool (approximately 8,000 square feet) complimented by clusters of feather stones, cascading water, colorful fish and aquatic plants
- Swimming pool of Mediterranean design in ceramic tile complete with whirlpool and sauna
- Concrete tower structure finished with imported brick
- Formal garden and landscaped grounds covering the entire site
- Elegantly decorated lobby with Granite floors and specially designed wood coffered ceiling
- Twin elevators complete with double opening doors and custom cab interiors

SPECIAL EQUIPMENT

- Gas sending fireplaces with marble hearths and custom mantels to most of the suites
- Refuse chute on each floor
- Built-in vacuum system complete with all accessories and 30 foot hose
- Security door system with individual television entry phones in each suite

GENERAL

- Interior partition walls to be 3 1/2" steel stud with 1/2" gypsum taped and filled
- Walls finished with 3 coats of high quality latex paint
- For noise abatement, partywalls have resilient soundbar and acoustic tape on both sides of double walls

- Wall-to-wall carpet designed and created in Los Angeles exclusively for St. Moritz
- Mouldings installed around all windows and doors
- Baseboard to be installed in all suites

DOORS

- Interior Heritage doors to be painted, 1 3/4" solid core
- Italian hardware in polished brass designed by Cini Boeri of Fusital. Mortise lock on suite entries

WINDOWS

- Panoramic windows by Westcraft, custom color and double glazed
- Double track curtain rails with elegant sheers

LIVING-DINING ROOM

- Ceiling to be inlaid with drop trim, defining living and dining room
- Dining room to have light fixture, or $500 cash allowance

BEDROOMS

- To have mirrored bypass closet doors
- Walk-in closets with convenient built-in closet organizers

LAUNDRY

- Laundry/utility room in each suite equipped with full size deluxe washer and dryer by Maytag

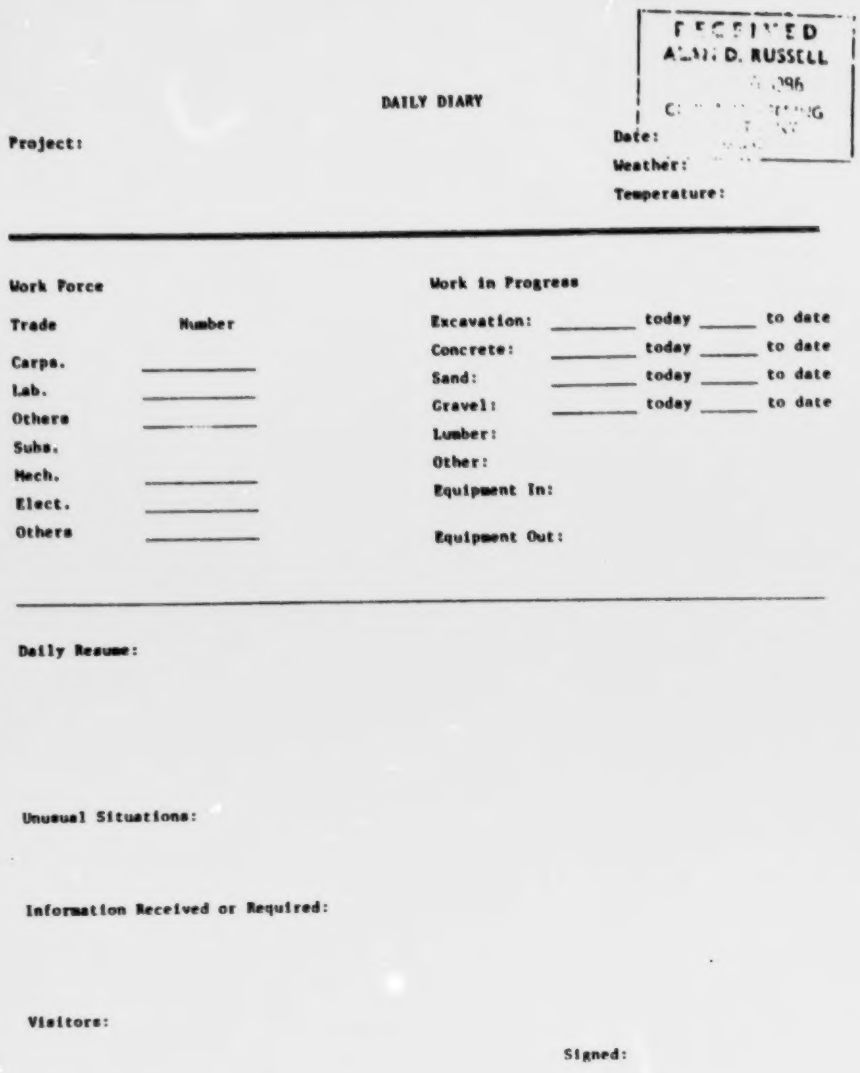
BATHROOMS & ENSUITES

- Italian marble bathroom and showers
- Italian vanity top with cabinets by Snaidero
- Quiet one-piece Kohler water closet
- Kohler bidet in most master bathrooms
- Vanity sink by Kohler
- Tub to be "Karisma", by Jacuzzi (non-jetted)
- Hardware imported from Europe

KITCHENS

- Heat resistant counter tops by Avonite with Italian cabinets by Snaidero
- Fridge, 36" Sub-Zero, side by side
- Cook top by Thermador
- Oven by Thermador
- Stainless steel dishwasher by Thermador
- Microwave by General Electric
- Sink by Alape or Kohler
- Instant hot water dispenser by ISE
- Garburator by ISE
- Hardwood floors

Figure 2-2 Finishing Features for Case Study One.



RECEIVED
ALAN D. RUSSELL
1996

DAILY DIARY

Project:

Date:
Weather:
Temperature:

Work Force

Trade	Number
Carps.	________
Lab.	________
Others	________
Subs.	
Mech.	________
Elect.	________
Others	________

Work in Progress

Excavation: ______ today ______ to date
Concrete: ______ today ______ to date
Sand: ______ today ______ to date
Gravel: ______ today ______ to date
Lumber:
Other:
Equipment In:

Equipment Out:

Daily Resume:

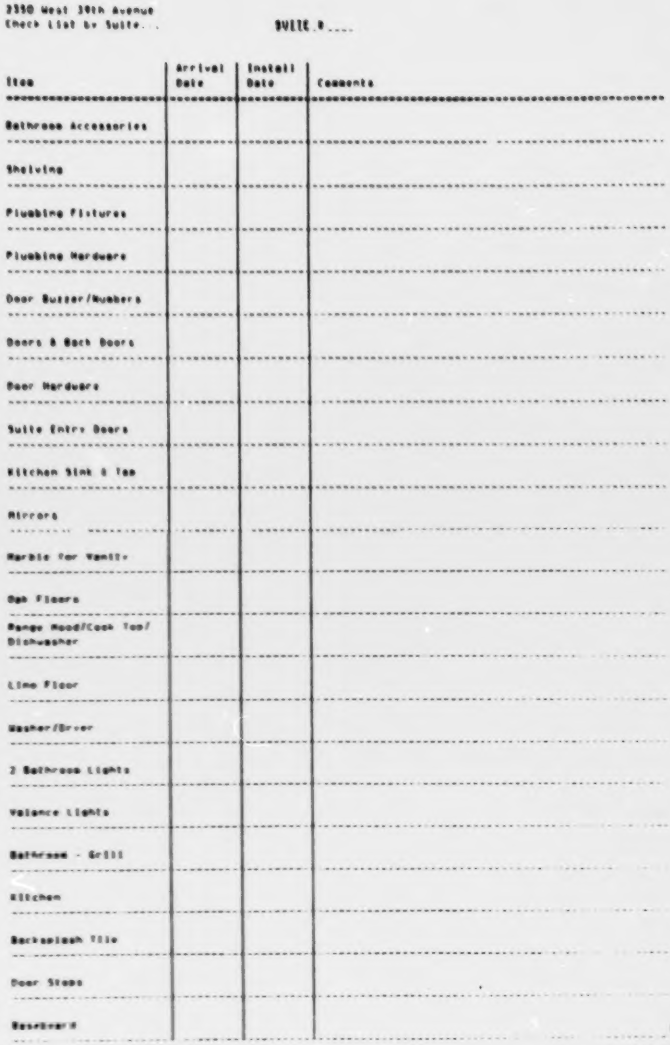
Unusual Situations:

Information Received or Required:

Visitors:

Signed:

Figure 2-3 Contractor Daily Site Report



2350 West 39th Avenue
Check List by Suite...

SUITE #....

Item	Arrival Date	Install Date	Comments
Bathroom Accessories			
Shelving			
Plumbing Fixtures			
Plumbing Hardware			
Door Buzzer/Numbers			
Doors & Back Doors			
Door Hardware			
Suite Entry Doors			
Kitchen Sink & Tap			
Mirrors			
Marble for Vanity			
Oak Floors			
Range Hood/Cook Top/ Dishwasher			
Lino Floor			
Washer/Dryer			
2 Bathroom Lights			
Valance Lights			
Bathroom - Grill			
Kitchen			
Backsplash Tile			
Door Stops			
Baseboard			

Figure 2-4 Contractor Suite Finishing Checklist

2.3.2 Summary of the Scheduling/Updating Process

Our experience with this project is summarized in diary form. Where appropriate, only selected schedule formats are shown to reduce the bulk of the report. Emphasis is placed on activity scoping and sequencing and schedule updating.

January 20/86 Meeting Follow-up

Firm provided copy of bar chart schedule. Visit to site made. Preliminary computer network schedule prepared based on contractor bar chart and our previous experience with high-rise projects in Montreal.

February 14/86 Meeting with Contractor

Meeting held for review of preliminary network schedule represented in bar chart form, see figure 2-5. Additional information provided included an activity list, a list of dates, a short cycle matrix schedule, a short cycle bar chart and a blank procurement form. Feedback requested dealt with scoping, sequencing and activity durations, a list of subtrades and procurement information. The projected completion date was October 20, 1986, although it was stated to be optimistic since site finishing work was not included and front end foundation work was optimistically estimated.

March or April 1986 - Meeting for Feedback from JS

Considerable time elapsed before JS provided feedback. He had reviewed in detail the preliminary schedule and was making some use of it. His comments were written directly on the bar chart and they were augmented by notes recorded during the meeting. These notes were further augmented in the June 16,1986 meeting. The schedule had been used by the firm to help them refine their strategy for building the substructure.

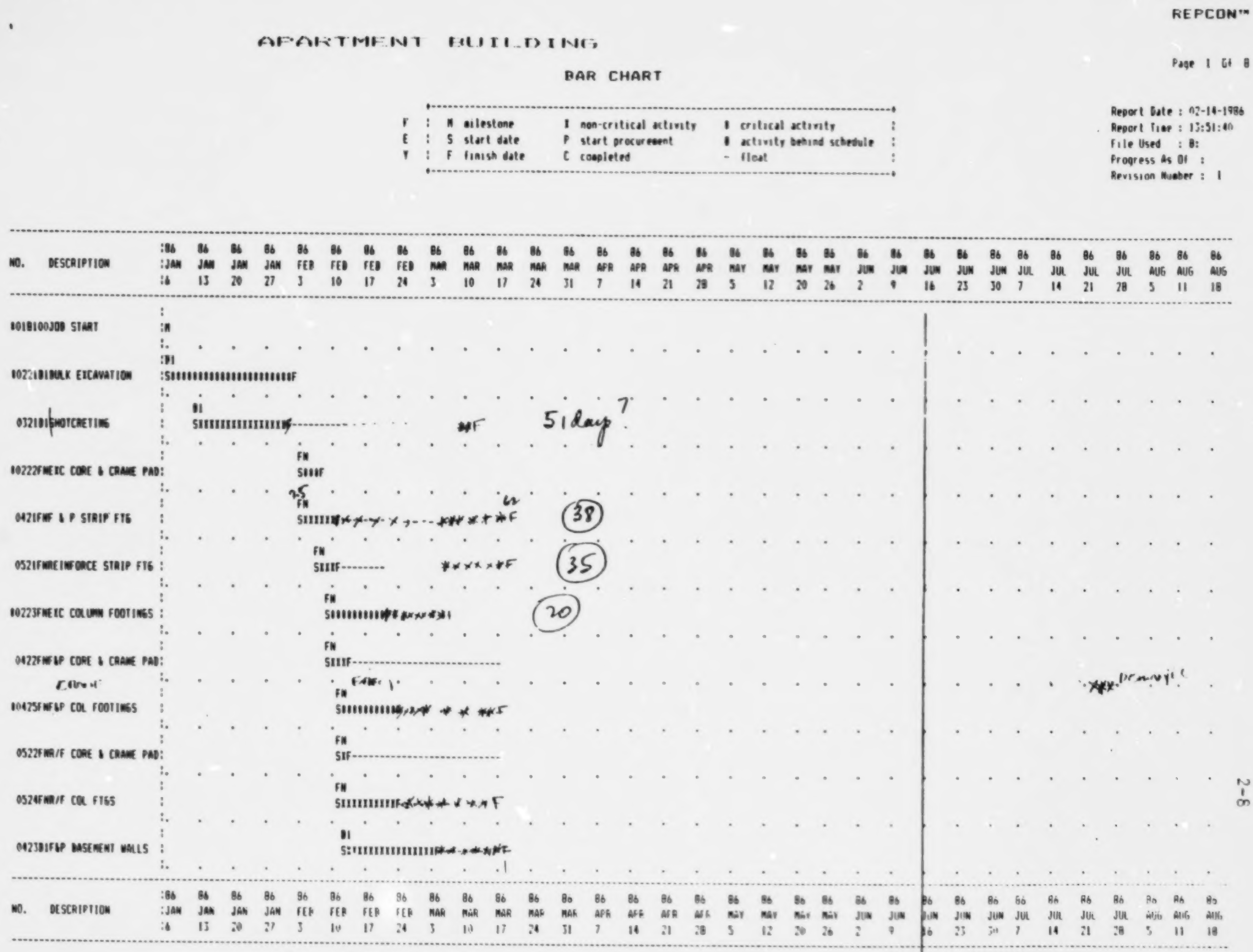
Interestingly, most of the feedback dealt with incorporating many more activities into the computer based schedule than on the original contractor schedule and specifying time frames during which specific activities were to be performed as opposed to logical sequences of activities. Also, knowledge of the durations of subtrade work was weak and little consultation had taken place with subtrades about schedule issues.

Other comments received dealt with the need to develop coding systems that facilitate the integration of cost accounting, estimating and planning and scheduling. Limited feedback was received on procurement.

Due to other pressures on both the side of the contractor and research team, the interaction dropped to a low level until June. However, we continued to monitor the job photographically and this information was used to update the schedule later.

June 16, 1986 Meeting

The meeting was held to get back on track and to review the current status of the project in order to collect information to refine and update the schedule. Notes were made both separately and directly on the February 14, 1986 schedule.



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APARTMENT BUILDING                                              REPCON™

                         BAR CHART                              Page 1 Of 8

        +----------------------------------------------------------------+
     K  :  M  milestone      I  non-critical activity   #  critical activity            :   Report Date : 02-14-1986
     E  :  S  start date     P  start procurement       #  activity behind schedule     :   Report Time : 13:51:40
     Y  :  F  finish date    C  completed               -  float                        :   File Used   : B:
        +----------------------------------------------------------------+                  Progress As Of  :
                                                                                            Revision Number :  1

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001B100JOB START      :M
0221B1BULK EXCAVATION :S#######################F
0321B1SHOTCRETING     :   SIIIIIIIIIIIIIII#-------
00222FNEIC CORE & CRANE PAD:       S###F
0421FNF & P STRIP FTG :          SIIIIII#
0521FNREINFORCE STRIP FTG :        SIIIF--------
00223FNEIC COLUMN FOOTINGS :       S##########
0422FNF&P CORE & CRANE PAD:        SIIIF------------------------
00425FNF&P COL FOOTINGS :            S##########
0522FNR/F CORE & CRANE PAD:          SIF--------------------------
0524FNR/F COL FTGS    :              SIIIIIIIIII
04230IF&P BASEMENT WALLS :            S:IIIIIIIIIIIIIII

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Figure 2-5 Preliminary Computer-Based Schedule.

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Pool walls

South
Middle
North

Figure 2-5 (cont'd)

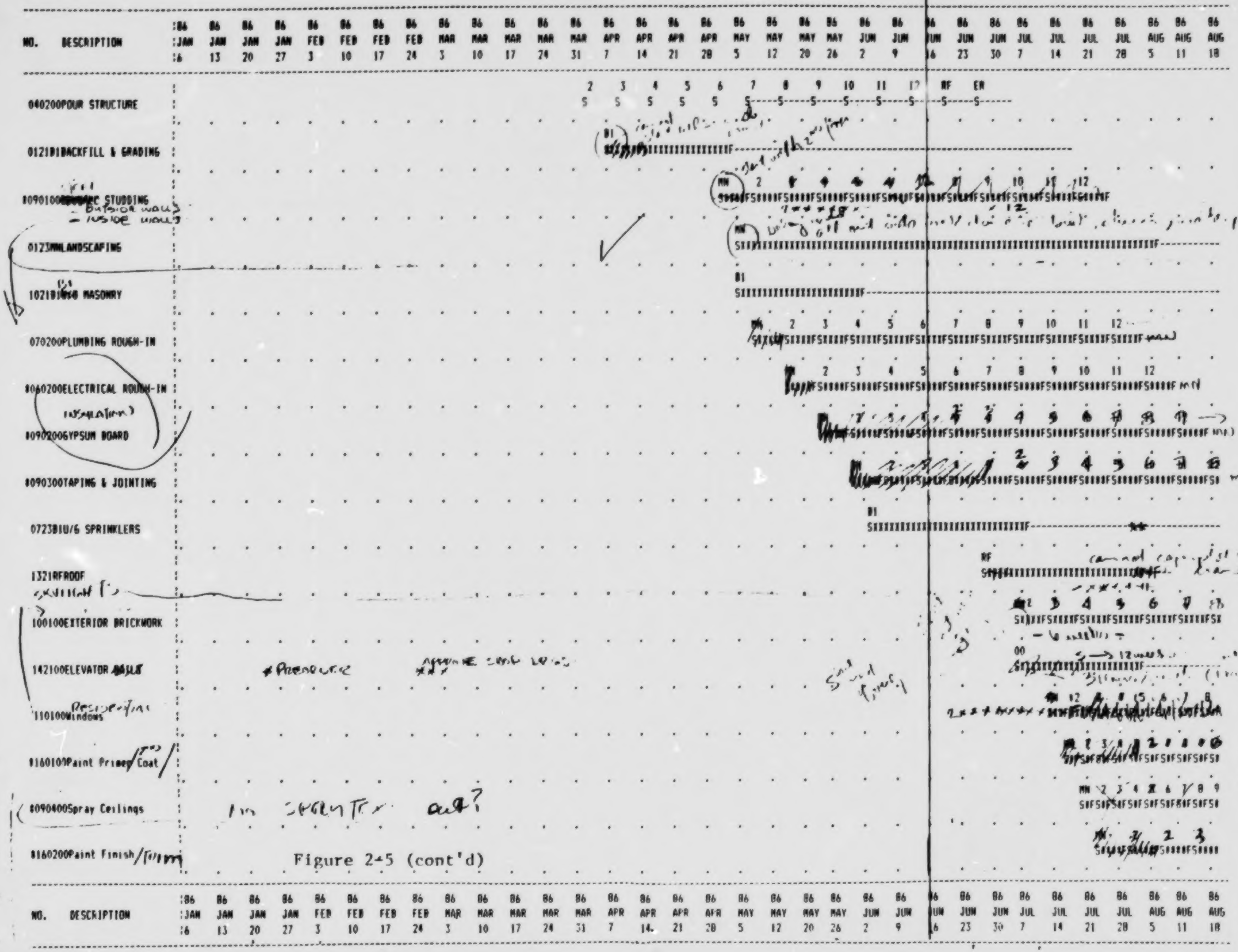

Figure 2-5 (cont'd)

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                          :6   13  20  27  3   10  17  24  3   10  17  24  31  7   14  21  28  5   12  20  26  2   9   16  23  30  7   14  21  28  5   11  18
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```

MARBLE (BATHROOMS)
WOOD FLOORS KIT

APPLIANCES

- 6 weeks

[illegible]

[illegible] (MM) 5 days. (will have shop drawings with it) 1 week to manufacture 1 week approval - same time as lobby feature
- WATERPROOF DECK (SUSP. SLAB) (MM) - brickwork + stucco has to be completed first / 18 days [Done in two stages around August] Aug 24.
- CANOPY ——— Front canopy - will be a separate item. Will be done just before lobby features.
- BRICK IN CANOPY ——— Brickwork.
- MN FLOOR FINISHES —
- [illegible] ———→ Architectural Precast - the I Procurement Shop Drawings 2 weeks (incl. approval) // Manufacture 1 week // Installation 1 week.
- HARD LANDSCAPING - Planters, etc - Done before waterproofing - 1 month of work
- SOFT LANDSCAPING - Mulch, plants, trees (see schedule)
- [illegible] - After waterproofing (granite pavers - 2-3 weeks)
- WATERPROOF BRICK - (all brick; probably part of brickwork contract - acid wash then seal - 3-4 weeks - start after brickwork completed
- PAINT STUCCO - Right after stucco done (Sept 21) Painter activity - 2 weeks.
- [illegible] - Mechanical/Electrical Stage → start June/July - has to be done before waterproofing
Decorative stuff

Figure 2-5 (cont'd)

Shown as lobby features

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                                                                                                                Page 7 Of 8
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NO.   DESCRIPTION           :86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86
                            :AUG  AUG  SEP  SEP  SEP  SEP  SEP  OCT  OCT  OCT  OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DEC  DEC
                            :18   25   2    8    15   22   29   6    14   20   27   3    10   17   24   1    8    15   22   29
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                            :
 040200POUR STRUCTURE       :
                            :.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                            :
 0121B1BACKFILL & GRADING   :
                            :.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                            :
#090100DRYWALL STUDDING     :
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 0123MMLANDSCAPING          :-------------------------------------------------------
                            :.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                            :
 1021B1U/G MASONRY          :----------------------
                            :.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                            :
 070200PLUMBING ROUGH-IN    :
                            :.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                            :
#060200ELECTRICAL ROUGH-IN  :
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                            :
#090200GYPSUM BOARD         :
                            :.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                            :12
#090300TAPING & JOINTING    :S####F
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                            :
 0723B1U/G SPRINKLERS       :---------------------------------------------------
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 1321RFROOF                 :
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                            : 7    8    9    10   11   12   RF
 100100EXTERIOR BRICKWORK   :SXXXXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXF------
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                            :
 142100ELEVATOR RAILS       :---
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                            :  9  10  11  12
 110100Windows              :XFSXXFSXXFSXXFSXXF-------------------------------
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                            :10 11 12
#160100Paint Primer Coat    :S#FS#FS#F
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                            : 9 10 11 12
#090400Spray Ceilings       :S#FS#FS#FS#F
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                            :   5     6     7     8     9     10    11    12
#160200Paint Finish         :##FS####FS####FS####FS####FS####FS####FS####FS####F
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NO.   DESCRIPTION           :86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86
                            :AUG  AUG  SEP  SEP  SEP  SEP  SEP  OCT  OCT  OCT  OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DEC  DEC
                            :18   25   2    8    15   22   29   6    14   20   27   3    10   17   24   1    8    15   22   29
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Figure 2-5 (cont'd)

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                          :86    86    86   86    86    86    86    86     86   86    86    86    86   86    86    86    86    86    86  86
NO.   DESCRIPTION         :AUG   AUG   SEP  SEP   SEP   SEP   SEP   OCT    OCT  OCT   OCT   NOV   NOV  NOV   NOV   DEC   DEC   DEC   DEC DEC
                          :18    25    2    8     15    22    29    6      14   20    27    3     10   17    24    1     8     15    22  29
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                          :     6     7     8     9     10    11    12
 180100Doors & Hardware   :IIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIF--------------
                          :.     .     .    .     .     .     .     .      .    .     .     .     .    .     .     .     .     .     .   .
                          : 7  8  9 10 11 12
 070300Plumbing Finishing :SIFSIFSIFSIFSIFSIF-------------------------------
                          :.     .     .    .     .     .     .     .      .    .     .     .     .    .     .     .     .     .     .   .
                          : 8  9 10 11 12
 170100Kitchen Cabinets   :SIFSIFSIFSIFSIF-----------------------------
                          :.     .     .    .     .     .     .     .      .    .     .     .     .    .     .     .     .     .     .   .
                          : 5   6   7   8   9  10  11  12
 060300Electrical Finishing:FSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF--------------------
                          :.     .     .    .     .     .     .     .      .    .     .     .     .    .     .     .     .     .     .   .
                          :
 142200EL MOTORS & CONTROLS:IIIIIIIF---------------
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                          :   4    5    6    7    8    9    10   11   12
 150100Stucco             :IIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIF-----
                          :.     .     .    .     .     .     .     .      .    .     .     .     .    .     .     .     .     .     .   .
      [illegible]         :        00
 142300PLATFORM & CABLES  :        SIIIIIIIIF---------------
                          :.     .     .    .     .     .     .     .      .    .     .     .     .    .     .     .     .     .     .   .
                          :                  00
 142400ELEV. DOORS & CABS :                  SIIIIIIIIIIIIIIIIIIF---------------
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                          :                                 2 3 4 5 6 7 8 9101112
*190100Carpeting          :                                 SFSFSFSFSFSFSFSFSFSFSF
                          :.     .     .    .     .     .     .     .      .    .     .     .     .    .     .     .     .     .     .   .
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                          :86    86    86   86    86    86    86    86     86   86    86    86    86   86    86    86    86    86    86  86
NO.   DESCRIPTION         :AUG   AUG   SEP  SEP   SEP   SEP   SEP   OCT    OCT  OCT   OCT   NOV   NOV  NOV   NOV   DEC   DEC   DEC   DEC DEC
                          :18    25    2    8     15    22    29    6      14   20    27    3     10   17    24    1     8     15    22  29
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Figure 2-5 (cont'd)

The following summary was made of the current status, strategy and progress.

> A 5 day cycle for the superstructure had been achieved with a slab pour every Wednesday. The 8th floor slab was to be poured June 18/86.
>
> New exterior brick was being ordered. The developer was not happy with the colour of first batch that had arrived. Installation would be delayed. Delivery now scheduled for the last week of July. Brickwork installation would take 6 weeks, and the crew would work 7 days a week to make up lost time. The production rate would be 3 floors a week or a floor every 2 days.
>
> Electrical rough-in had started in the basement as of June 9 and would be finished by June 23.
>
> Masonry in basement had started as of June 13 and would be finished by June 20.
>
> The 2nd and 3rd floors were ready for layout of studding.
>
> Windows would be late and should now arrive at the end of July. They would be installed at the rate of 2 days/floor. They would lag behind brickwork by one week.
>
> Stucco would lag one week behind windows and take 2 days/floor.
>
> Exterior enclosure work would be performed by corkscrewing around the building. Scaffolding would be erected on all sides simultaneously.
>
> Logic should be brickwork--->window---> stucco.
>
> Once the brickwork was complete, efforts would be made to pick up the pace on windows and stucco by boosting crew size. The goal was to minimize the time gap between finishing of brick and finishing of windows and stucco. (The issue of crewing up was cited repeatedly as the strategy for making up lost time. It never really happened in any consistent way.)
>
> Permanent power was to be installed by the end of August. Depends on BC Hydro and finish of electrical work in basement.
>
> The contractor was now predicting substantial completion to be December 31/86
>
> Studding was to be treated in two passes - Stud layout + Exterior studding -----> Internal studding.
>
> For the ground floor, only internal studding is required, and this floor is the last one in the location sequence. Estimated durations were, for exterior studding - 3 days/floor; and for interior studding - 3 days/flr. Exterior boarding would take 2 days/flr and would lead the brickwork activity by one floor. Interior boarding was forecast to take 6 days/flr. It would be followed by three passes of tape and fill, each of 5 days/flr duration.
>
> The need to incorporate window treatment under the headings of skylights, residential windows/balcony doors and storefront glazing was also noted.

As a follow-up to this meeting, a new schedule was prepared (June 27, 1986), which incorporated elements of the discussion. No attempt was made to change the schedule to reflect activities that were already finished. This schedule was sent by courier to JS for review. His attention was also directed to the issue of work continuity. Many activity ends had not been properly tied off so excessive float existed in several cases.

June 27, 1986 Schedule

See figures 2-6 and 2-7, a linear planning chart and bar chart respectively for the June 27 schedule. The completion date was now predicted to be December 29, 1986. From the linear planning chart it can be seen that production rates were not well matched. As well, studding and rough-in work was lagging far behind structural work. It was also observed that additional work locations should be added for the entrance canopy structure and for site finishing.

July 15, 1986 Site Meeting

Meeting held with JS and BJ. A review of the June 27, 1986 schedule was made. JS had marked up the bar chart in consultation with BJ. By now the firm was relying on the computer based schedule. None other existed.

Attention was now starting to be focused on finishing activities, inspections and how time could be made up.

Issues discussed were as follows.

Roofing on top of elevator penthouse and on top of penthouse floor would involve four operations: place membrane, place insulation, place ballast and place flashing. The total duration would be 12 days, with the membrane taking 6. As soon as the membrane was placed, insulation in exterior and interior walls on lower floors could start.

Inspections would be required as follows:

rough-in electrical ---> inspection
rough-in mechanical ---> inspection
seal holes in slab ---> fire inspection

The general contractor is responsible for arranging for fire inspection. Electrical and mechanical trades were responsible for their own arrangements.

Considerable discussion took place about the finishing activity sequence for suites. The results of the discussion are shown in figure 2-8. They were incorporated into the schedule and later revised as shown in figure 2-9. Again the contractor was seeking greater detail in order to treat coordination interfaces in an attempt to minimize time to complete.

As a follow-up to the meeting, the schedule was modified the same day to incorporate the findings of the discussion. Further minor modifications were made on July 22, 1986.

July 22, 1986 Schedule

The linear planning chart for the July 22, 1986 schedule is shown in figure 2-10. The projected completion date is now January 7, 1987. Based on information given to date, production rates are not well matched. To date, no discussions have been held with finishing trades to discuss production rates. Work continuity has been assumed. The concentration of activities all starting on September 10,1986 does not constitute good planning.

JS is concerned about the continuing schedule slippage. He is prepared to encourage BJ to be more cooperative in terms of recording actual performance. Up to now the research team has been responsible for tracking progress. No official update of the schedule has occurred as attention has been focused on obtaining an accurate scoping of the work.

BJ claims that the computer bar chart schedule is hard to read. We respond with a short cycle bar chart in large type - see figure 2-11. BJ starts to use it but does not keep it up consistently.

REPCON™

APARTMENT BUILDING

LINEAR PLANNING CHART

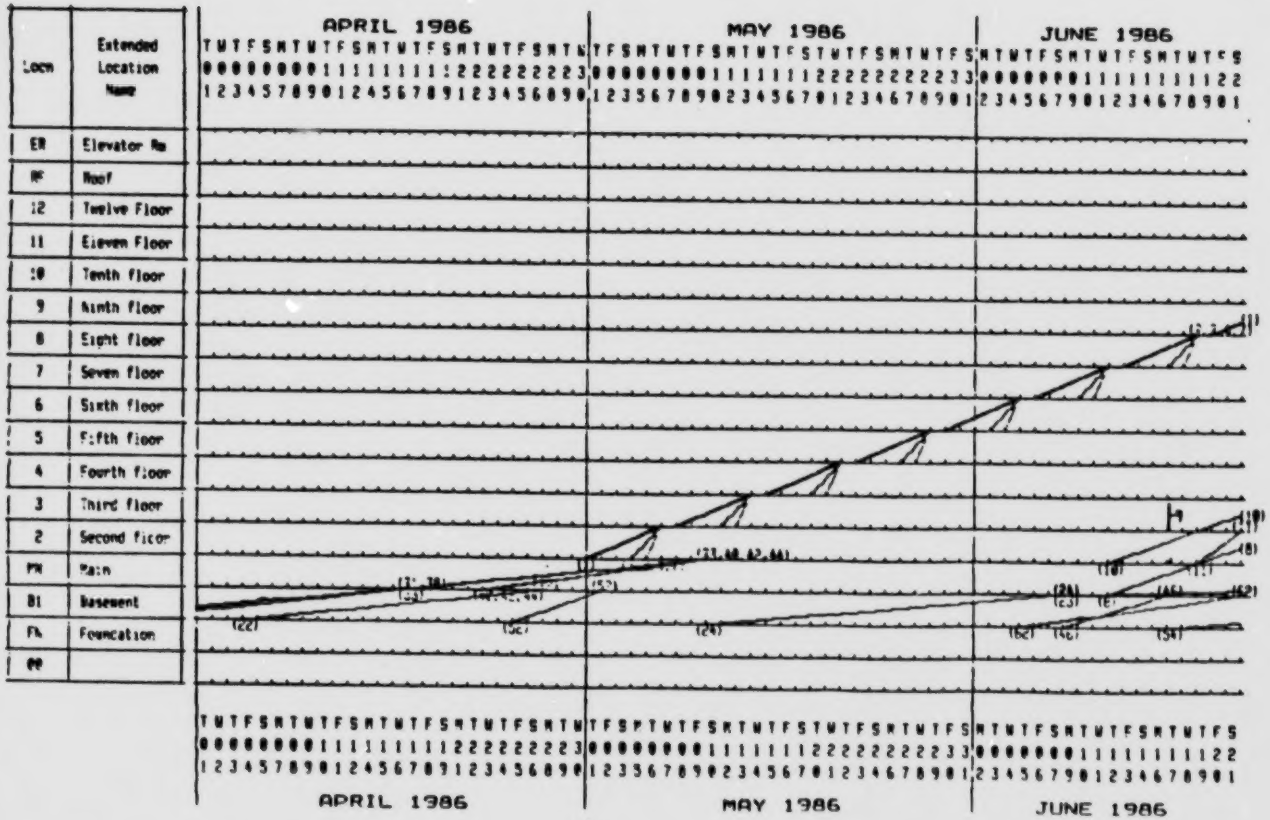
K	*	critical act.
E	@	act. behind sch.
Y	p	act. has procurement seq.
	c	completed

Report Date : 1986-06-27
Report Time : 11:31:12

File Used : C:\DATAFIL\
Progress as of :
Revision Number : 0
Window Schedule :
From 1APR86 To 31JAN87
From FN To ER

ACTIVITY KEY

Act No		Act Description
*(1)	040100	FORM STRUCTURE
(2)	040200	POUR STRUCTURE
(3)	050100	R/F STRUCTURE
(4)	060100	ELECT CONDUIT STRUCT
(7)	070100	PLBS SLVS STRUCTURE
(8)	070200	PLUMBING ROUGH-IN
(10)	090100	EXT/INT STUDDING
(11)	090200	PLACE EXT. BOARD
(22)	012201	FOOTING DRAINS
(23)	0123[illegible]	LANDSCAPING
(24)	012401	BACKFILL & GRADING
*(21)	042301	F&P BASEMENT WALLS
*(23)	0426[illegible]	F & P SUSPENDED SLAB
*(38)	052301	R/F BASEMENT WALLS
*(40)	0525[illegible]	R/F SUSPENDED SLAB
*(42)	0621[illegible]	CONDUIT SUSP SLAB
*(44)	0721[illegible]	PLBS SLVS SUSP SLAB
(46)	102101	BASEMENT MASONRY
(52)	202101	DAMP PROOFING
(54)	072301	BASEMENT SPRINKLERS
(62)	062301	ELECT ROUGH-IN BSMT



Mary

Figure 2-6 June 27, 1986 Linear Planning Chart Schedule.

REPCON™

APARTMENT BUILDING

LINEAR PLANNING CHART

Report Date : 1986-06-27
Report Time : 11:34:18

File Used : C:\DATAFIL
Progress as of :
Revision Number : 0
Window Schedule :
From 1APR86 To 31JAN87
From FN To ER

K | ●	critical act.
E | 0	act. behind sch.
Y | ø	act. has procurement seq.
| c	completed

we have
12 lifts.

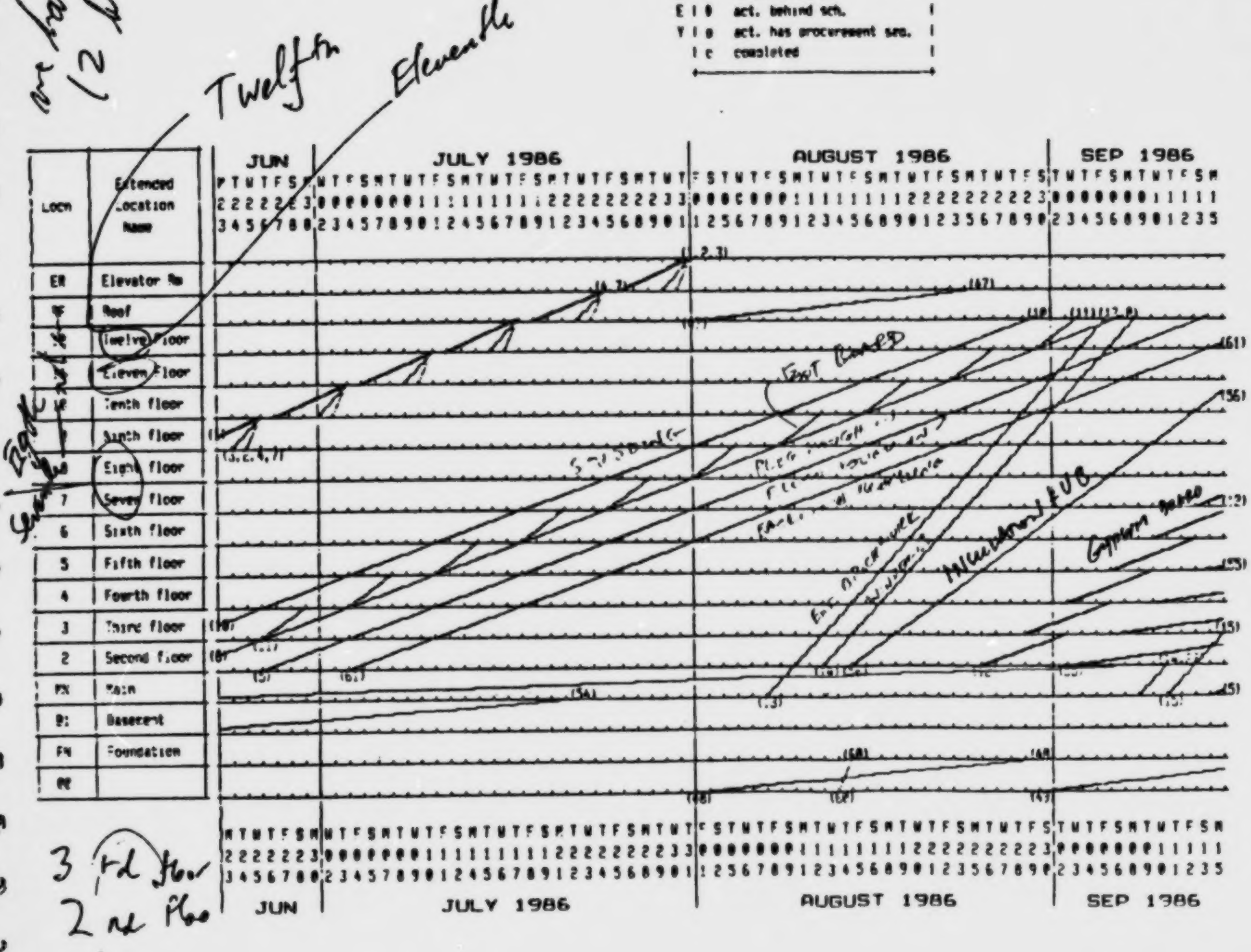


Figure 2-6 (cont'd)

ACTIVITY KEY
Act No Act Description
*(1) 040100 FORM STRUCTURE
(2) 040200 POUR STRUCTURE
(3) 050100 R/F STRUCTURE
(4) 052100 ELECT CONDUIT STRUCT
(5) 062200 ELECTRICAL ROUGH-IN
(7) 070100 PLBG SLVG STRUCTURE
(8) 070200 PLUMBING ROUGH-IN
(10) 090100 EXT/INT STUDDING
(11) 090200 PLACE EXT. BOARD
*(12) 090400 PLACE GYPSUM BOARD
(13) 100100 EXTERIOR BRICKWORK
(14) 110100 WINDOWS
(15) 150100 STUCCO
(23) 012300 LANDSCAPING
*(47) 122100 ROOF
(48) 142100 ELEVATOR RAILS
(49) 142200 ELEV MTRS & CONTROLS
(54) 072301 BASEMENT SPRINKLERS
*(55) 090500 TAPE AND FILL
(56) 090600 INSULATION / VB
(60) 012500 REMOVE CRANE
(61) 010100 BACKING & BLOCKING

APARTMENT BUILDING

REPCON™

LINEAR PLANNING CHART

K | * critical act.
E | 0 act. behind sch.
Y | a act. has procurement sen.
  | c completed

Report Date : 1986-06-27
Report Time : 11:37:58

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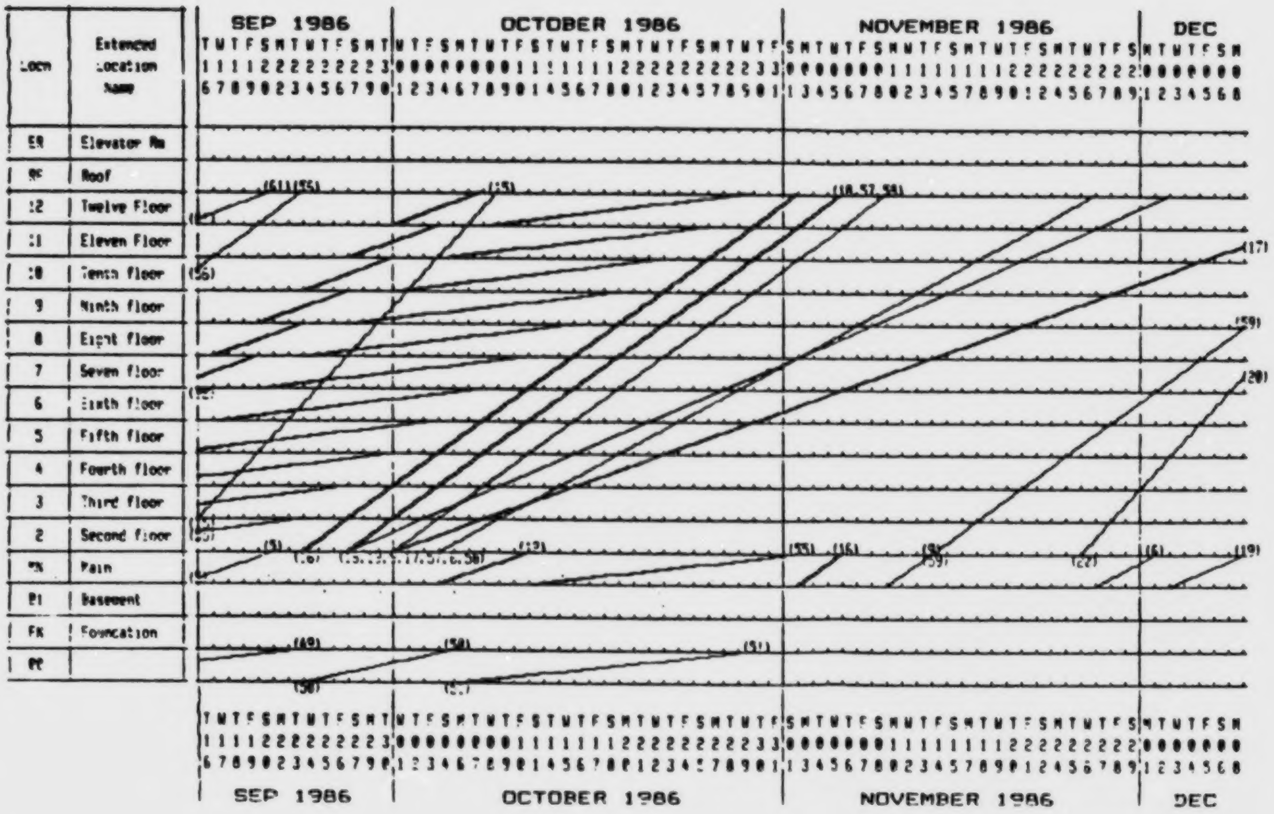
Progress as of :
Revision Number : 0
Window Schedule :
From 1APR86 To 31JAN87
From FN To ER



ACTIVITY KEY

Act No		Act Description
(5)	060200	ELECTRICAL ROUGH-IN
(6)	060300	ELECTRICAL FINISHING
(9)	070300	PLUMBING FINISHING
*(12)	090400	PLACE GYPSUM BOARD
(15)	150100	STUCCO
*(16)	160100	PAINT PRIMER COAT
*(17)	160200	PAINT FINISH / TRIM
*(18)	170100	KTCHN & BATHRM CABTS
(19)	180100	DOORS & HARDWARE
(20)	190100	CARPETING
(49)	142200	ELEV MTRS & CONTROLS
(50)	142300	PLATFORM & CABLES
(51)	142400	ELEV DOORS & CABS
*(55)	090500	TAPE AND FILL
(56)	030600	INSULATION / VB
(57)	200100	BATHROOM MARBLE
(58)	210100	WOOD FLOORS KITCHEN
(59)	210200	FINISH KITCHEN FLOOR
(61)	010100	BACKING & BLOCKING

Figure 2-6 (cont'd)

REPCON™

APARTMENT BUILDING

LINEAR PLANNING CHART

```
+----------------------------------+
K | *  critical act.               |
E | #  act. behind sch.            |
Y | o  act. has procurement seq.   |
  | c  completed                   |
+----------------------------------+
```

Report Date : 1986-05-27
Report Time : 11:41:40

File Used : C:\DATAFIL\
Progress as of :
Revision Number : 0
Window Schedule :
From 1APR86 To 31JAN87
From FN To ER

ACTIVITY KEY
Act No Act Description
*(17) 160200 PAINT FINISH / TRIM
(20) 190100 CARPETING
(59) 210200 FINISH KITCHEN FLOOR

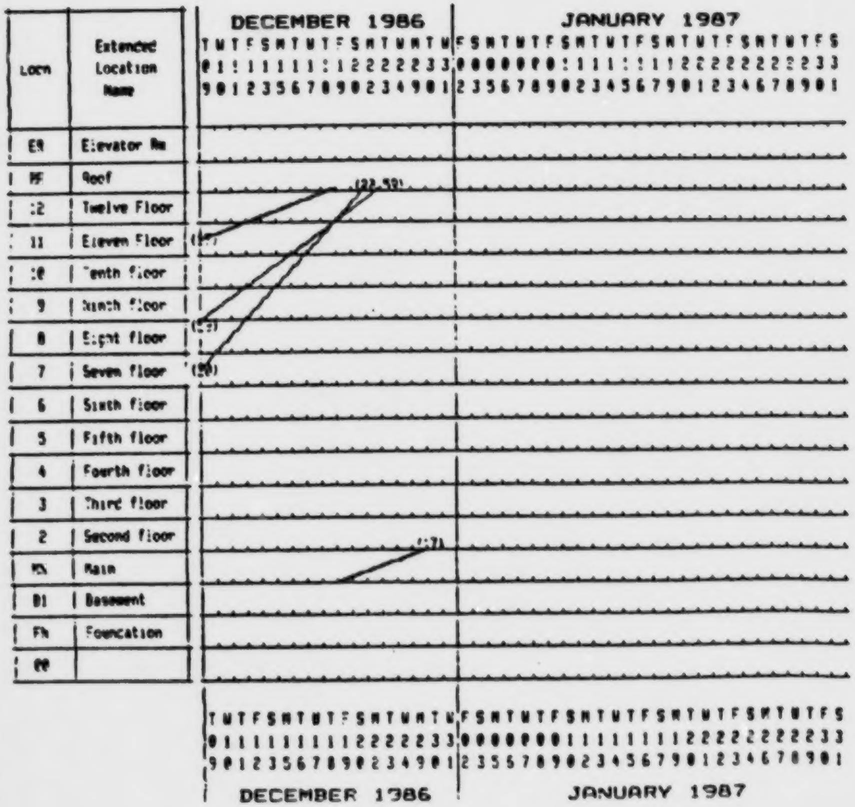


Figure 2-6 (cont'd)

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                                                                                                        REPCON(TM)
                         APARTMENT BUILDING

                                                                                                      Page 1 of 8
                                                  B A R   C H A R T
                                    +-----------------------------------------------------------+
                                  K |  m milestone       x non-critical activity   * critical activity            |   Report Date     : 1986-06-27
                                  E |  s start date      p start procurement       @ activity behind schedule     |   Report Time     : 14:39:42
                                  Y |  f finish date     c completed               - float                        |   File Used       : C:\DATAFIL\
                                    +-----------------------------------------------------------+                      Progress as of  :
                                                                                                                       Revision Number : 0
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                          |MAYMAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG SEP SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV DEC DEC DEC
                          |11  5  12  20  26  2   9   16  23  30  7   14  21  28  5   11  18  25  2   8   15  22  29  6   14  20  27  3   10  17  24  1   8   15
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                          |
 0:0:00 PROJECT START     |
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
*022:01 BULK EXCAVATION   |
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 032:01 SHOTCRETING       |
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 0222FN EXC CORE & CRANE PAD|
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
*0421FN F & P STRIP FOOTINGS|
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
*0521FN REINFORCE STRIP FTG |
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0223FN EXC COLUMN FOOTING |
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0422FN F&P CORE + CRANE PAD|
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0425FN F&P COL FOOTINGS  |
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0522FN R/F CORE 7 CRANE PAD|
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0524FN R/F COL FTGS      |
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0121FN INSTALL CRANE     |
                          |.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
-----------------------------------------------------------------------------------------------------------------------------------------------
NO.  DESCRIPTION          |86 86 86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86  86
                          |MAYMAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG SEP SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV DEC DEC DEC
                          |11  5  12  20  26  2   9   16  23  30  7   14  21  28  5   11  18  25  2   8   15  22  29  6   14  20  27  3   10  17  24  1   8   15
-----------------------------------------------------------------------------------------------------------------------------------------------
```

dur.

fin.

?

past Time 0

Figure 2-7   June 27, 1986 Bar Chart Schedule.

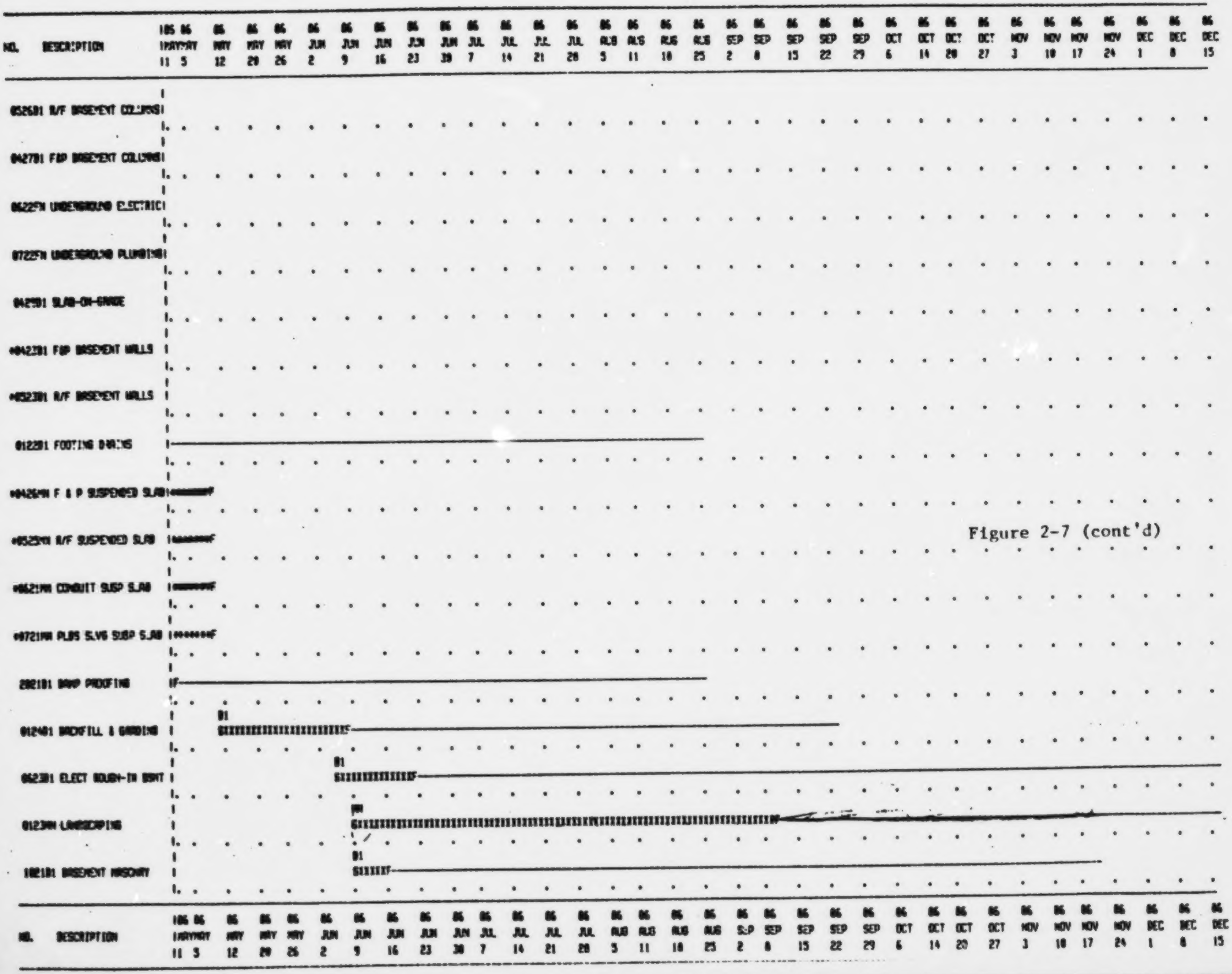


Figure 2-7 (cont'd)

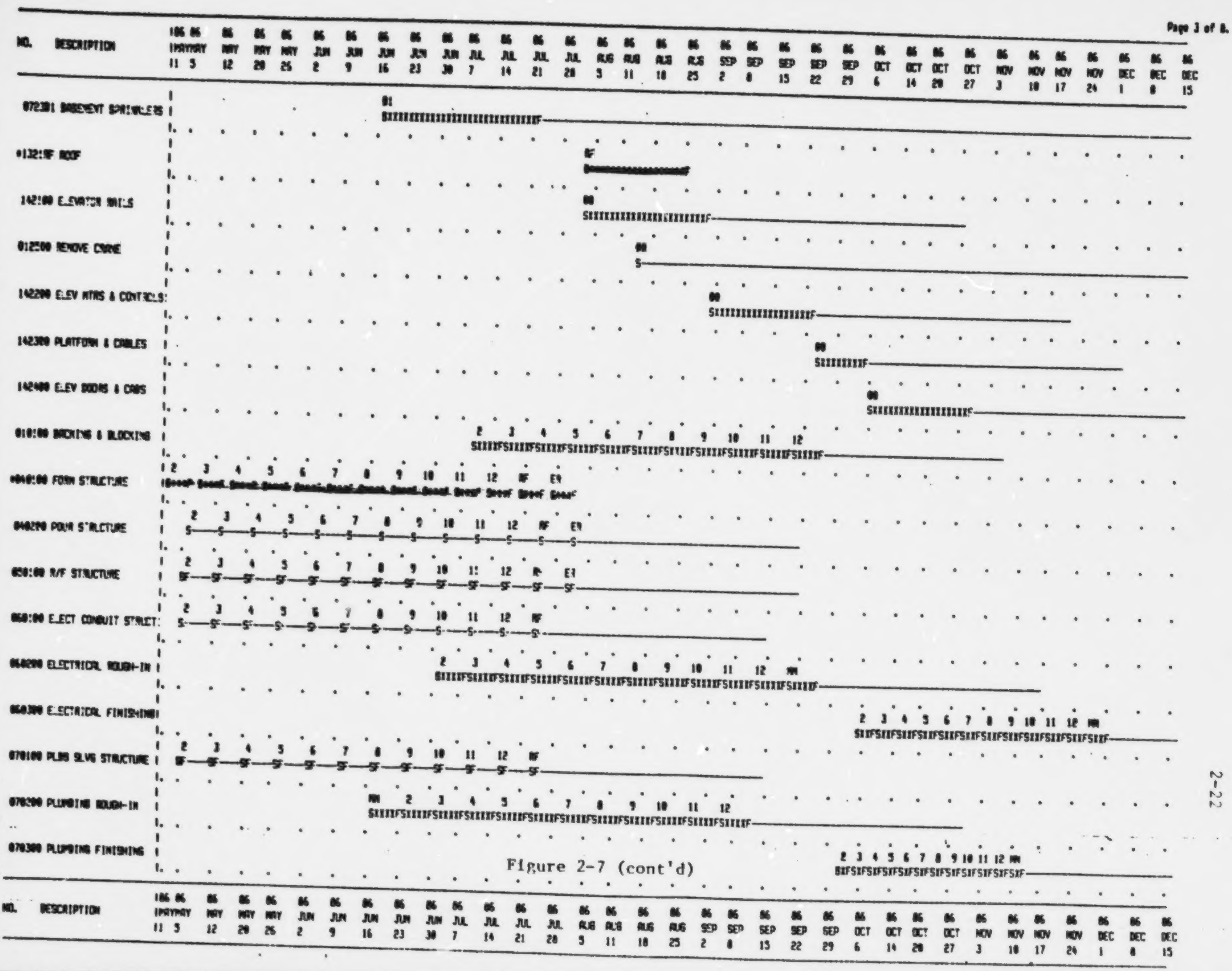


Figure 2-7 (cont'd)

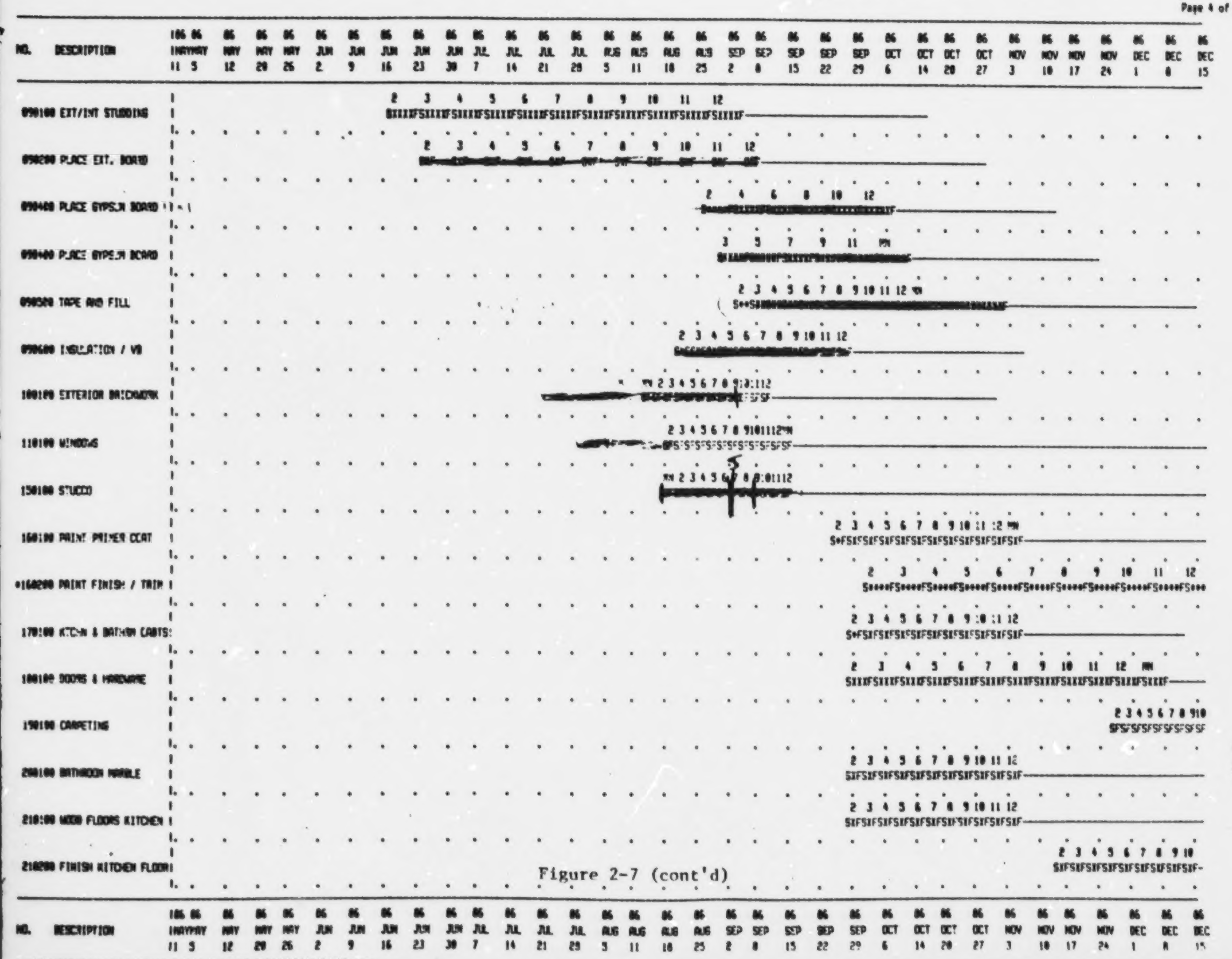


Figure 2-7 (cont'd)

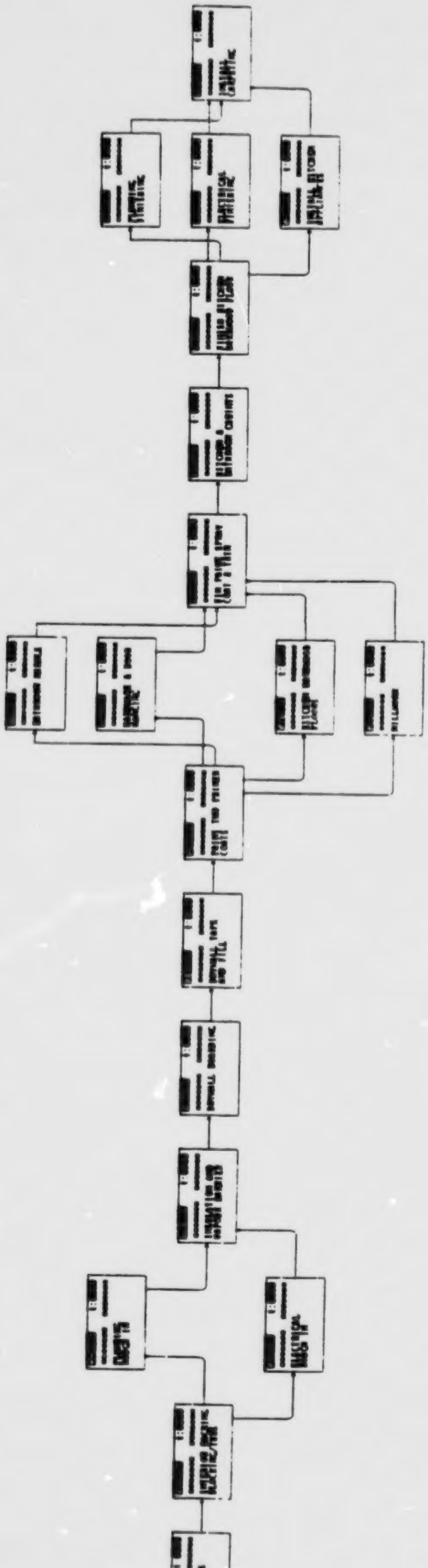


Figure 2-8 Finishing Activity Sequence.

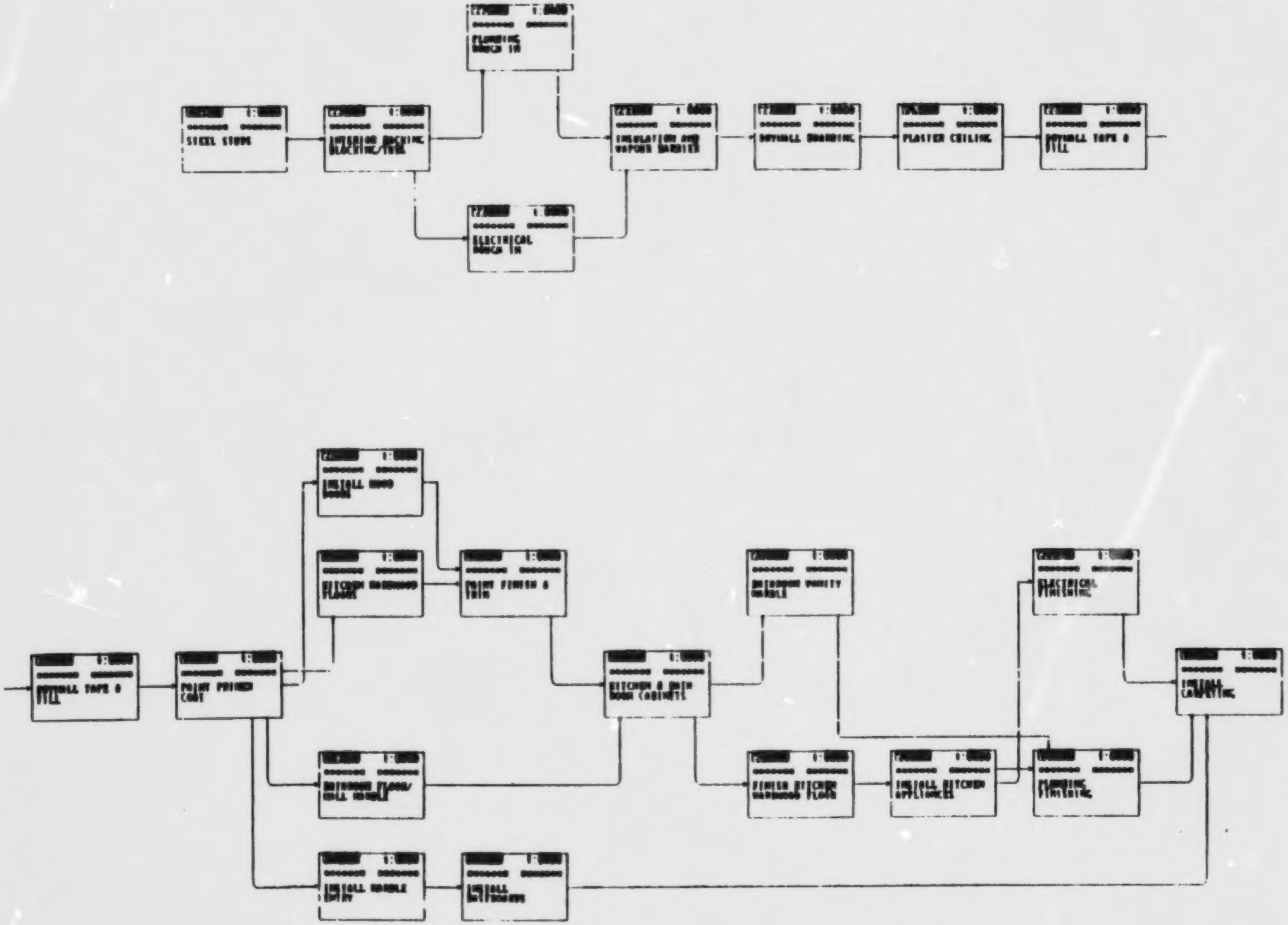

STEEL STUDS
INTERIOR BACKING BLOCKING/TRIM
PLUMBING ROUGH IN
ELECTRICAL ROUGH IN
INSULATION AND VAPOUR BARRIER
DRYWALL BOARDING
PLASTER CEILING
DRYWALL TAPE & FILL
DRYWALL TAPE & FILL
PAINT PRIMER COAT
INSTALL WOOD DOORS
KITCHEN HARDWOOD FLOORS
PAINT FINISH & TRIM
BATHROOM FLOOR/ WALL MARBLE
INSTALL MARBLE ENTRY
INSTALL BASEBOARDS
KITCHEN & BATH ROOM CABINETS
BATHROOM VANITY MARBLE
FINISH KITCHEN HARDWOOD FLOOR
INSTALL KITCHEN APPLIANCES
ELECTRICAL FINISHING
PLUMBING FINISHING
INSTALL CARPETING

Figure 2-9 Revised Finishing Activity Sequence.

APARTMENT BUILDING

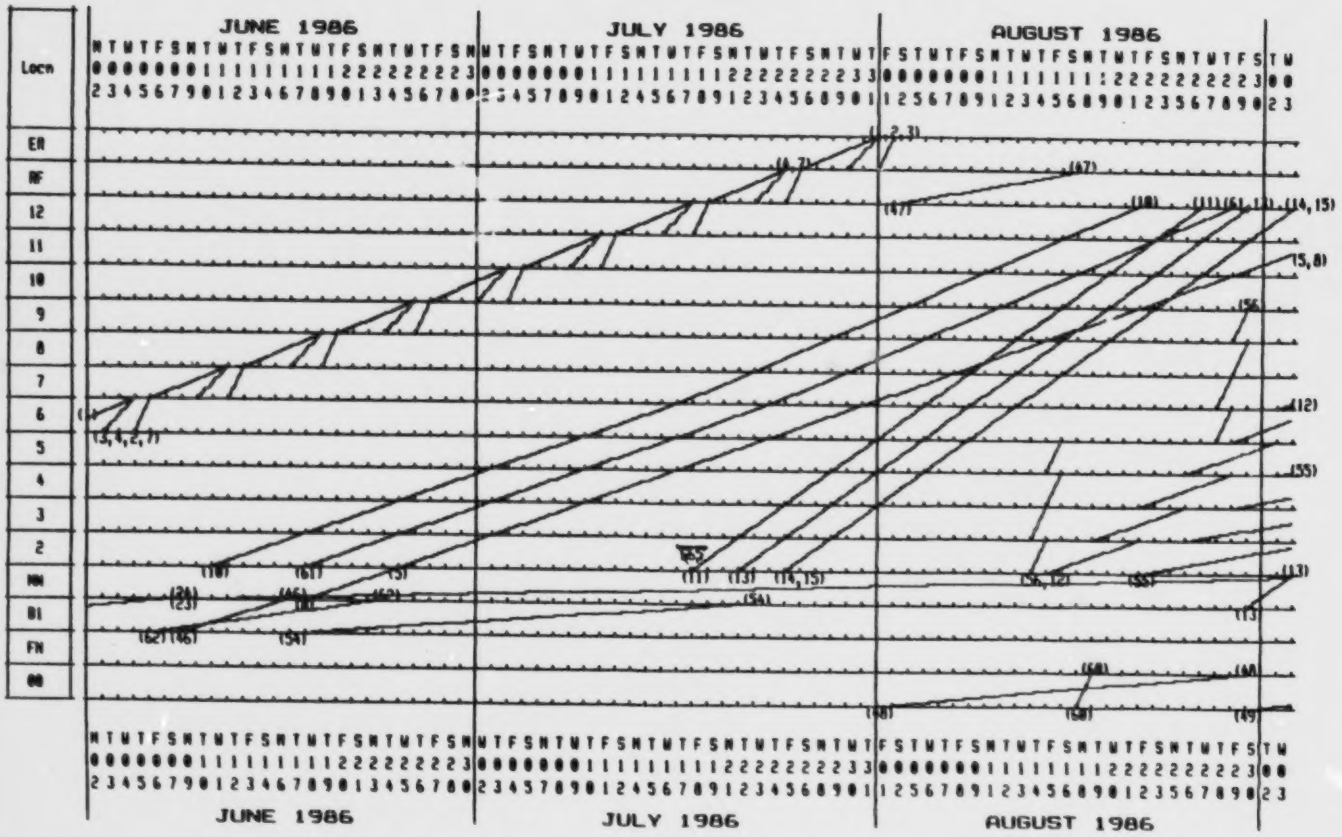
REPCON™

LINEAR PLANNING CHART

K | * critical act.
E | 0 act. behind sch.
V | p act. has procurement seq.
| c completed

Report Date : 1986-07-22
Report Time : 12:20:29

File Used : C:\REPCONC\.
Progress as of :
Revision Number : 0
Window Schedule :
From 2JUN86 To 10JAN87
From FN To ER



ACTIVITY KEY

Act No	Act Description
(1) 040100	FORM STRUCTURE
(2) 040200	POUR STRUCTURE
(3) 050100	R/F STRUCTURE
(4) 060100	ELECT CONDUIT STRUCT
(5) 060200	ELECTRICAL ROUGH-IN
(7) 070100	PLBS SLVG STRUCTURE
(8) 070200	PLUMBING ROUGH-IN
(10) 090100	EXT/INT STUDDING
(11) 090200	PLACE EXT. BOARD
(12) 090400	PLACE GYPSUM BOARD
(13) 100100	EXTERIOR BRICKWORK
(14) 110100	WINDOWS
(15) 150100	STUCCO
(23) 0123MM	LANDSCAPING
(24) 0124B1	BACKFILL & GRADING
(46) 1021B1	BASEMENT MASONRY
(47) 1321RF	ROOF
(48) 142100	ELEVATOR RAILS
(49) 142200	ELEV MTRS & CONTROLS
(54) 0723B1	BASEMENT SPRINKLERS
(55) 090500	TAPE AND FILL
(56) 090600	INSULATION / VB
(60) 012500	REMOVE CRANE
(61) 010100	BACKING/BLKG/SUBBASE
(62) 0623B1	ELECT ROUGH-IN BSMT.
*(65) 010202	START EXT BOARD

Figure 2-10 July 22, 1986 Linear Planning Chart Schedule.

REPCON™

APARTMENT BUILDING

LINEAR PLANNING CHART

```
+-----------------------------+
K | *  critical act.            |
E | @  act. behind sch.         |
Y | p  act. has procurement seq. |
  | c  completed                |
+-----------------------------+
```

```
Report Date : 1986-07-22
Report Time : 12:23:21

File Used : C:\REPCONC\.
Progress as of :
Revision Number : 0
Window Schedule :
  From 2JUN86 To 10JAN87
  From FN To ER
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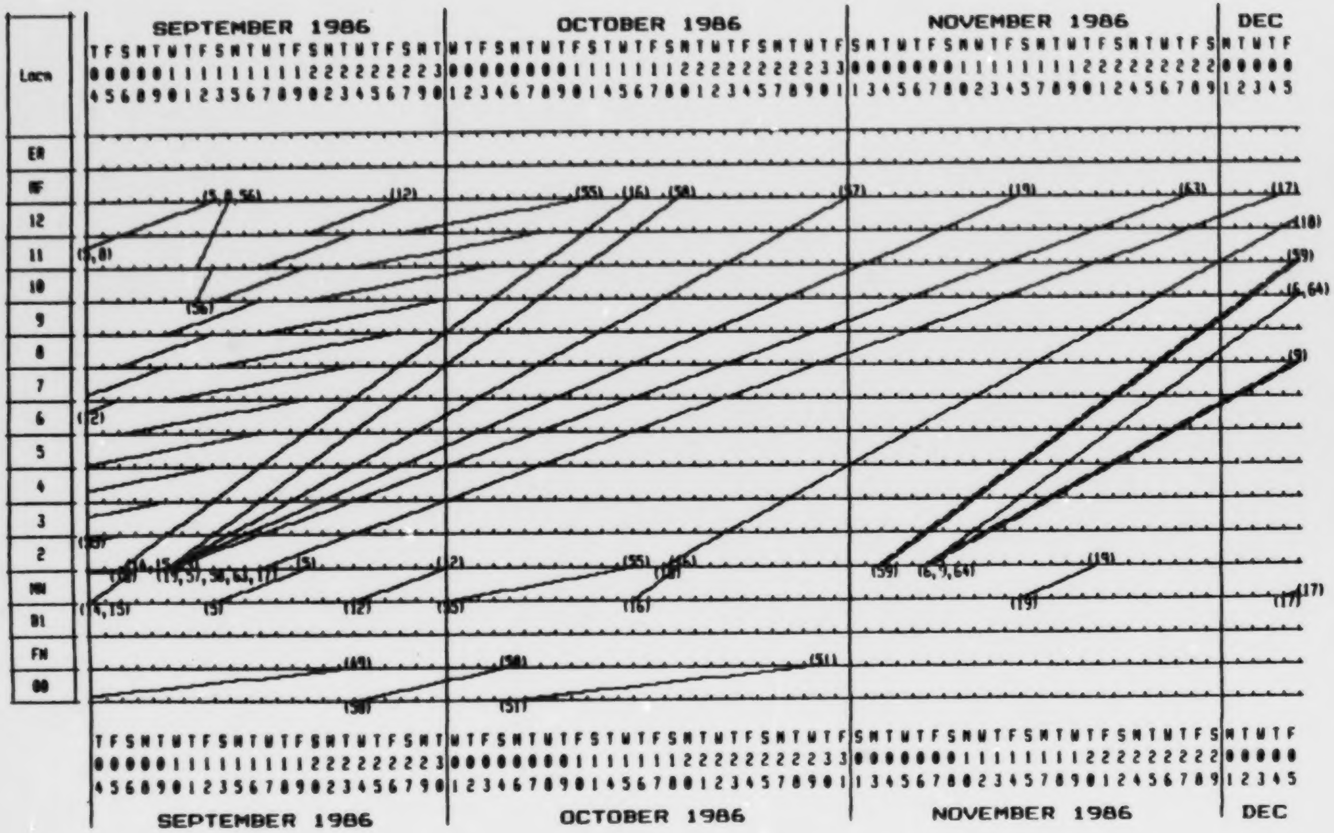


```
ACTIVITY KEY
    Act No Act Description
 ( 5) 060200 ELECTRICAL ROUGH-IN
 ( 6) 060300 ELECTRICAL FINISHING
 ( 8) 070200 PLUMBING ROUGH-IN
*( 9) 070300 PLUMBING FINISHING
 (12) 090400 PLACE GYPSUM BOARD
 (14) 110100 WINDOWS
 (15) 150100 STUCCO
 (16) 160100 PAINT 2 PRIMER COATS
 (17) 160200 PAINT FINISH / TRIM
 (18) 170100 KTCHN & BATHRM CABTS
 (19) 180100 DOORS & HARDWARE
 (23) 0123RN LANDSCAPING
 (49) 142200 ELEV MTRS & CONTROLS
 (50) 142300 PLATFORM & CABLES
 (51) 142400 ELEV DOORS & CABS
 (55) 090500 TAPE AND FILL
 (56) 090600 INSULATION / VB
 (57) 200100 BATHROOM MARBLE
 (58) 210100 WOOD FLOORS KITCHEN
*(59) 210200 FINISH KITCHEN FLOOR
 (63) 010200 MILLWORK
 (64) 220100 INSTALL KITCHEN APPL
```

Figure 2-10 (cont'd)

REPCON™

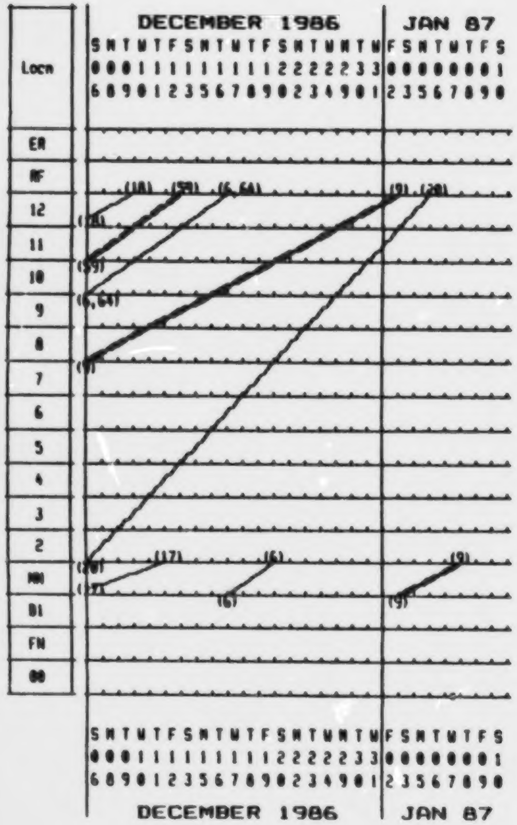
APARTMENT BUILDING

LINEAR PLANNING CHART

```
+------------------------------------+
K ! *  critical act.               |
E | @  act. behind sch.            |
Y | p  act. has procurement seq.   |
  | c  completed                   |
+------------------------------------+
```

```
Report Date : 1986-07-22
Report Time : 12:26:22

File Used : C:\REPCONC\
Progress as of :
Revision Number : 0
Window Schedule :
  From 2JUN86 To 10JAN87
  From FN To ER
```



```
ACTIVITY KEY
    Act No Act Description
 ( 6) 060300 ELECTRICAL FINISHING
*( 9) 070300 PLUMBING FINISHING
 (17) 160200 PAINT FINISH / TRIM
 (18) 170100 KTCHN & BATHRM CABTS
 (20) 190100 CARPETING
*(59) 210200 FINISH KITCHEN FLOOR
 (64) 220100 INSTALL KITCHEN APPL
```

Figure 2-10 (cont'd)

```
NO.    DESCRIPTION             |86    86    86    86    86    86    86    86    86
                               |JUL   JUL   JUL   AUG   AUG   AUG   AUG   SEP   SEP
                               |14    21    28    5     11    18    25    2     8
-------------------------------------------------------------------------------------
                               |     12    RF    ER
040200 POUR STRUCTURE          |     S     S     S
                               |
012481 BACKFILL & GRADING      |
                               |
062381 ELECT ROUGH-IN BSMT     |
                               |   START SEPT 1
0123MN LANDSCAPING             |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXF  NOT YET
                               |
102181 BASEMENT MASONRY        |
                               |    7    8    9    10   11   12
090100 EXT/INT STUDDING        |XXFSXXXFSXXXFSXXXFSXXXFSXXXFSXXXF
              NOT FINISHED     |
072381 BASEMENT SPRINKLERS     |XXXXXXXF
                               |    6     7    8    9    10   11   12
010100 BACKING/BLKG/SUBBASE    |XXFSXXXXFSXXXFSXXXFSXXXFSXXXFSXXXFSXXXF
DOORS-CABINETS-WINDOWS         |                                  3 WORKING DAYS LEFT
                               |    5     6     7     8     9     10    11    12
070200 PLUMBING ROUGH-IN       |XXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXF
                               |    5     6     7     8     9     10    11    12
060200 ELECTRICAL ROUGH-IN     |XXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXF
                               |
018202 START EXT BOARD         |     S
                               |     2  3  4  5  6  7  8  9  10 11 12
090200 PLACE EXT. BOARD        |     SXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXF
PLACE ANGLE   NEW ACTY  FIN. SAME DAY
                               |        2  3  4  5  6  7  8  9  10 11 12 MN
100100 EXTERIOR BRICKWORK      |        SXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXF
                               |           2  3  4  5  6  7  8  9  10 11 12 MN
110100 WINDOWS                 |           SXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXF
                               |           2  3  4  5  6  7  8  9  10 11 12 MN
150100 STUCCO                  |           SXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXF
                               |                 00
142100 ELEVATOR RAILS          |                 SXXXXXXXXXXXXXXXXXXXXXXF
                               |                  RF
1321RF ROOF                    |                  SXXXXXXXXXXXF
-------------------------------------------------------------------------------------
NO.    DESCRIPTION             |86    86    86    86    86    86    86    86    86
                               |JUL   JUL   JUL   AUG   AUG   AUG   AUG   SEP   SEP
                               |14    21    28    5     11    18    25    2     8
-------------------------------------------------------------------------------------
```

Figure 2-11 Short Cycle Bar Chart Schedule.

July 25, 1986 Meeting

JS provides us with a schedule for the exterior enclosure work. It is in the form of a matrix of dates versus construction operations, with floor level entered into the matrix - see figure 2-12. Input to this schedule was received from the masonry contractor in the form shown in figure 2-13. Note the schedule slippage entered on the figure. Again of interest is the continuing refinement in detail. What were three activities are now six: brickwork --> windows --> paper --> wire --> base coat --> acrylic. No attempt was made by the superintendent to update this schedule.

We discussed this schedule format with JS and BJ. BJ stated that if he received schedule information from us in that format he would use it and update it. We committed to producing a computer based work location schedule for them.

July 24, 1986 Schedule Update

The first formal update was performed using actual start and finish dates plus some assessment of time to complete for activities in progress. The new projected completion date was now January 16, 1987. Updated schedule provided to firm and is shown in figure 2-14.

August 8, 1986 Site Meeting

We are still not getting feedback from the site superintendent on actual performance. We are doing the site progress assessment and updating ourselves. See memo in figure 2-15 regarding site observations.

August 20, 1986 Site Meeting

A quick site tour was made to gauge progress. Noted very lean crews of subtrades. Discussion with JS ensued. He was satisfied with the current schedule. His present concerns were focused on installation of permanent power and getting the roof sealed. The number of unit presales was now 7.

August 26/86 Site Visit

Visited site to drop off new work location report. BJ not available. Met with JS and explained its use to him. He wanted a line added in order to record manpower usage. Also, he wanted a right hand column added to obtain a forecast of time to complete for ongoing activities. Took a tour of the building with him. Noticed that much of the work was being done through several passes - electrical, plumbing. Need to add activities for waterproofing of slab and reflecting pool to schedule. Received copy of their daily diary form.

September 4, 1986 Site Visit for Progress Assessment

September 9, 1986 Issue of Updated Schedule & Work Location Report

Schedule updated to show progress as of Sept 4/86. Completion date now February 3, 1987. Updated bar chart shown in figure 2-16. It was our view that further refinement of the finishing cycles were still required.

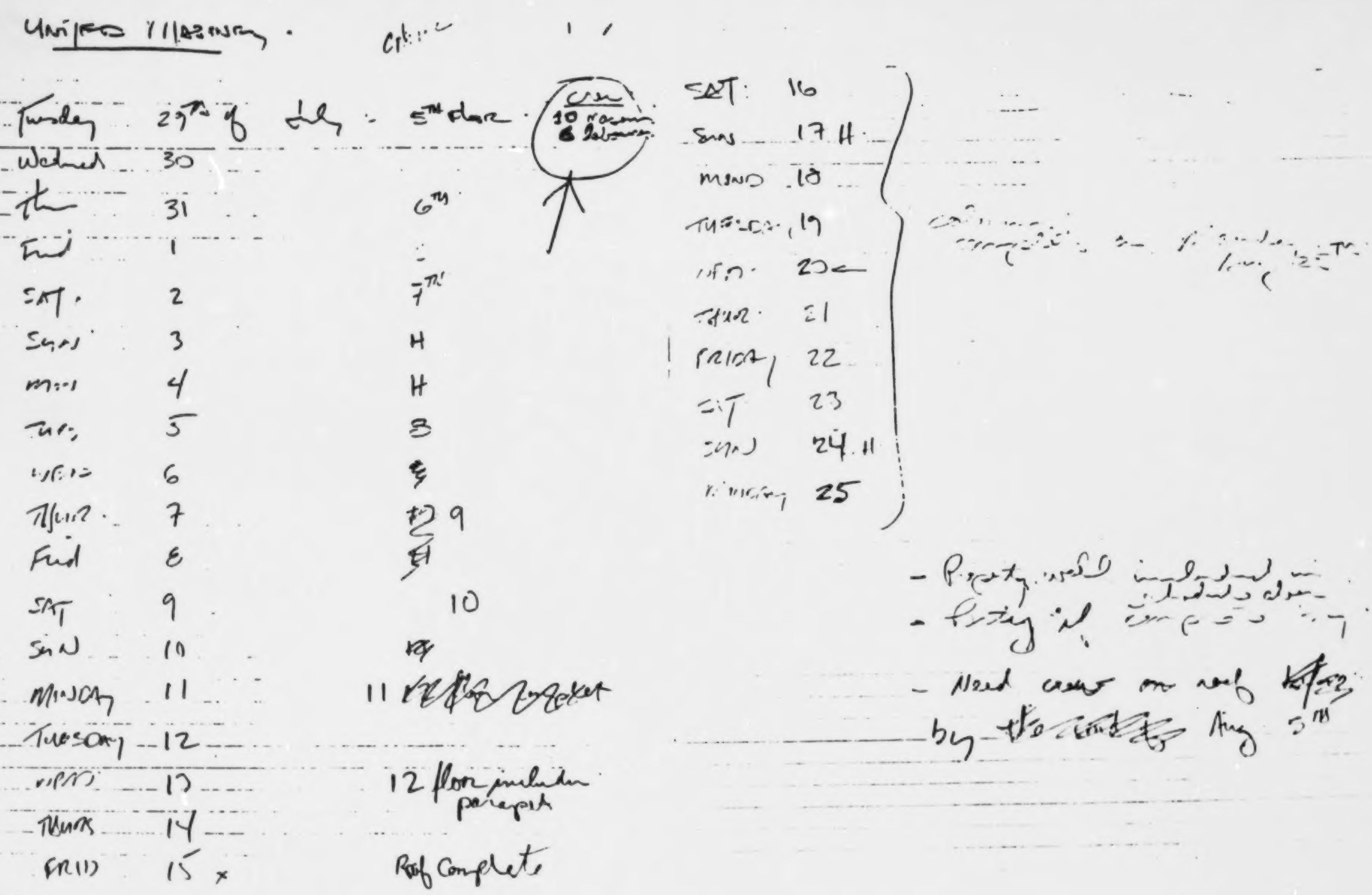
Schedule provided by [illegible]

JULY 24/86

EXTERIOR SCHEDULE

Date	UNITED MASONRY Brick work	O.G. INSTALL. Windows	VALLEY STUCCO Paper	Wire	Base coat	Acrylic	
28-Jul-86 Mo							
29-Jul-86 Tu	5 th Floor						
30-Jul-86 We		2nd Floor					
31-Jul-86 Th	6 th Floor		~~2nd Floor~~				
01-Aug-86 Fr				2nd Floor			
02-Aug-86 Sa	7 th Floor	3rd Floor			2nd Floor		
03-Aug-86 Su						2nd Floor	
04-Aug-86 Mo			~~3rd Floor~~				
05-Aug-86 Tu	8 th Floor			3rd Floor			
06-Aug-86 We		4th Floor			3rd Floor	3rd Floor	
07-Aug-86 Th	9 th Floor		~~4th Floor~~				
08-Aug-86 Fr	* Roof complete			4th Floor			
09-Aug-86 Sa	10 th Floor	5th Floor			4th Floor		
10-Aug-86 Su							
11-Aug-86 Mo	11 th Floor	2 ~~6th Floor~~	~~5th Floor~~			4th Floor	
12-Aug-86 Tu				5th Floor			
13-Aug-86 We	12 th Floor incl. parap.		2th Floor		5th Floor		
14-Aug-86 Th		3		2th Floor		5th Floor	
15-Aug-86 Fr		~~7th Floor~~			6th Floor		
16-Aug-86 Sa			3th Floor			6th Floor	
17-Aug-86 Su		4					
18-Aug-86 Mo		~~8th Floor~~		7th Floor			
19-Aug-86 Tu		5	4th Floor		2th Floor		
20-Aug-86 We		~~9th Floor~~		th Floor		2th Floor	
21-Aug-86 Th			5th Floor		th Floor		
22-Aug-86 Fr		6		th Floor		th Floor	
23-Aug-86 Sa		~~10th Floor~~			th Floor		
24-Aug-86 Su							
25-Aug-86 Mo	Columns		6th Floor			th Floor	
26-Aug-86 Tu		7		0th Floor			
27-Aug-86 We		~~11th~~ Floor			0th Floor		
28-Aug-86 Th			7th Floor			0th Floor	
29-Aug-86 Fr		8		th Floor			
30-Aug-86 Sa		~~12th~~ Floor			1th Floor		
31-Aug-86 Su						th Floor	
01-Sep-86 Mo			8th Floor				
02-Sep-86 Tu				12th Floor			
03-Sep-86 We					12th Floor	12th Floor	
04-Sep-86 Th							Scaffold
05-Sep-86 Fr							Down
06-Sep-86 Sa							
07-Sep-86 Su							

Figure 2-12 Contractor Exterior Enclosure Schedule.



UNITED MASONRY. [illegible]

Tuesday	29th of July	5th floor	CSW 10 masons 6 laborers
Wednes	30		
Thu	31	6th	
Fri	1		
SAT.	2	7th	
SUN	3	H	
MON	4	H	
TUES	5	8	
WED	6	8	
THUR.	7	9	
Frid	8		
SAT	9	10	
SUN	10		
MONDAY	11	11 [illegible]	
TUESDAY	12		
WED	13	12 floor including parapet	
THURS	14		
FRID	15 x	Roof Complete	

SAT:	16
SUN	17 H
MON	18
TUESDAY	19
WED.	20 ←
THUR.	21
FRIDAY	22
SAT	23
SUN	24 H
MONDAY	25

[illegible]

- Property [illegible]
- [illegible]
- Need crane on roof [illegible] by the ~~[illegible]~~ Aug 5th

Figure 2-13 Masonry Subtrade Schedule.

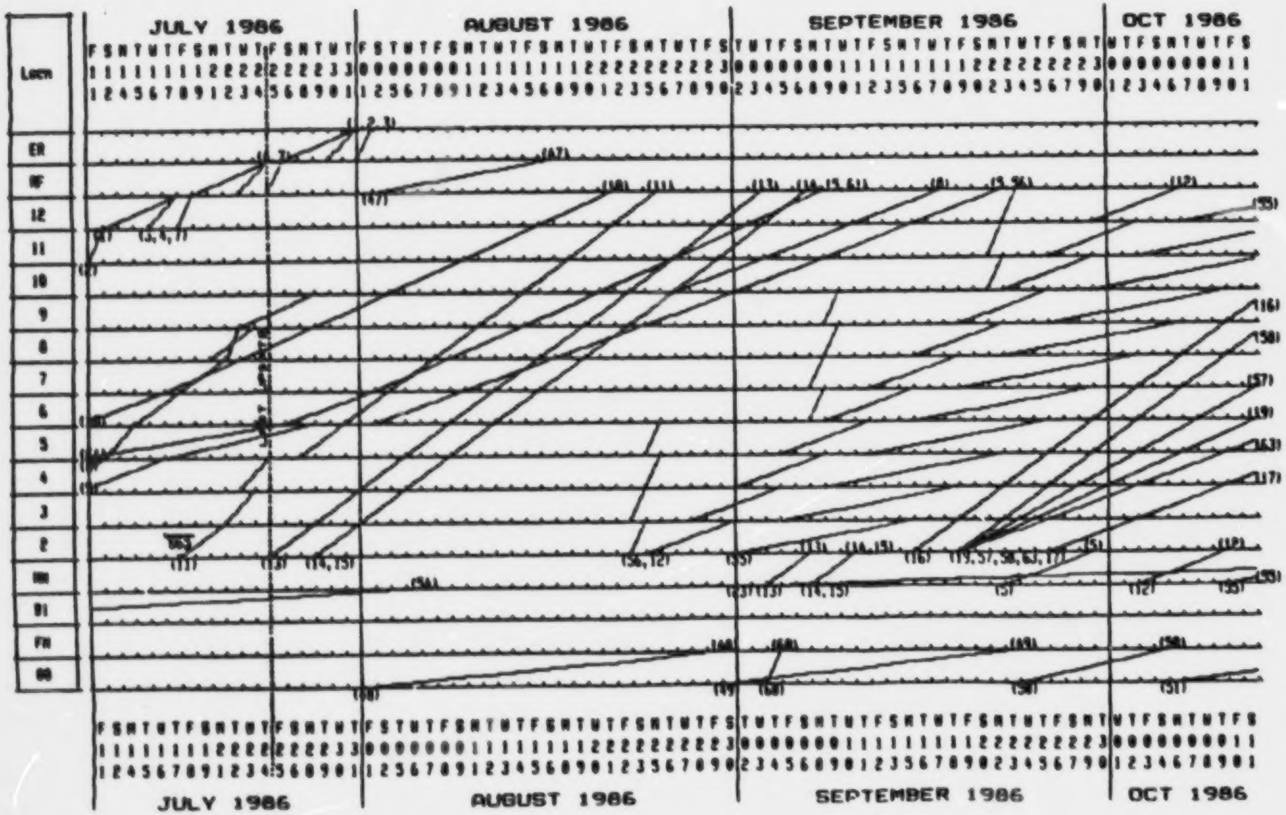
APARTMENT BUILDING

LINEAR PLANNING CHART

K | * critical act.
E | # act. behind sch.
Y | p act. has procurement seq.
| c completed

Report Date : 1986-07-30
Report Time : 12:39:44

File Used : C:\DATAFIL\
Progress as of : 1986-07-24
Revision Number : 0
Window Schedule :
From 6JUN86 To 31JAN87
From FN To ER



ACTIVITY KEY
Act No Act Description
(1) 040100 FORM STRUCTURE
(2) 040200 POUR STRUCTURE
(3) 050100 B/F STRUCTURE
c(4) 060100 ELECT CONDUIT STRUCT
(5) 060200 ELECTRICAL ROUGH-IN
c(7) 070100 PLBS SLVG STRUCTURE
(8) 070200 PLUMBING ROUGH-IN
(10) 090100 EXT/INT STUDDING
(11) 090200 PLACE EXT. BOARD
(12) 090400 PLACE GYPSUM BOARD
(13) 100100 EXTERIOR BRICKWORK
(14) 110100 WINDOWS
(15) 150100 STUCCO
(16) 160100 PAINT 2 PRIMER COATS
(17) 160200 PAINT FINISH / TRIM
(19) 180100 DOORS & HARDWARE
(23) 012300 LANDSCAPING
(47) 1321RF ROOF
(48) 142100 ELEVATOR RAILS
(49) 142200 ELEV MTRS & CONTROLS
(50) 142300 PLATFORM & CABLES
(51) 142400 ELEV DOORS & CABS
(54) 072301 BASEMENT SPRINKLERS
(55) 090500 TAPE AND FILL
(56) 090600 INSULATION / VB
(57) 200100 BATHROOM MARBLE
(58) 210100 WOOD FLOORS KITCHEN
(60) 012500 REMOVE CRANE
(61) 010100 BACKING/BLKG/SUBBASE
(63) 010200 MILLWORK
*(65) 010202 START EXT BOARD

windows
+ millwork follow

steel studs
di valves
insulation follows
+ drywall

Figure 2-14 July 24, 1986 Schedule Update.

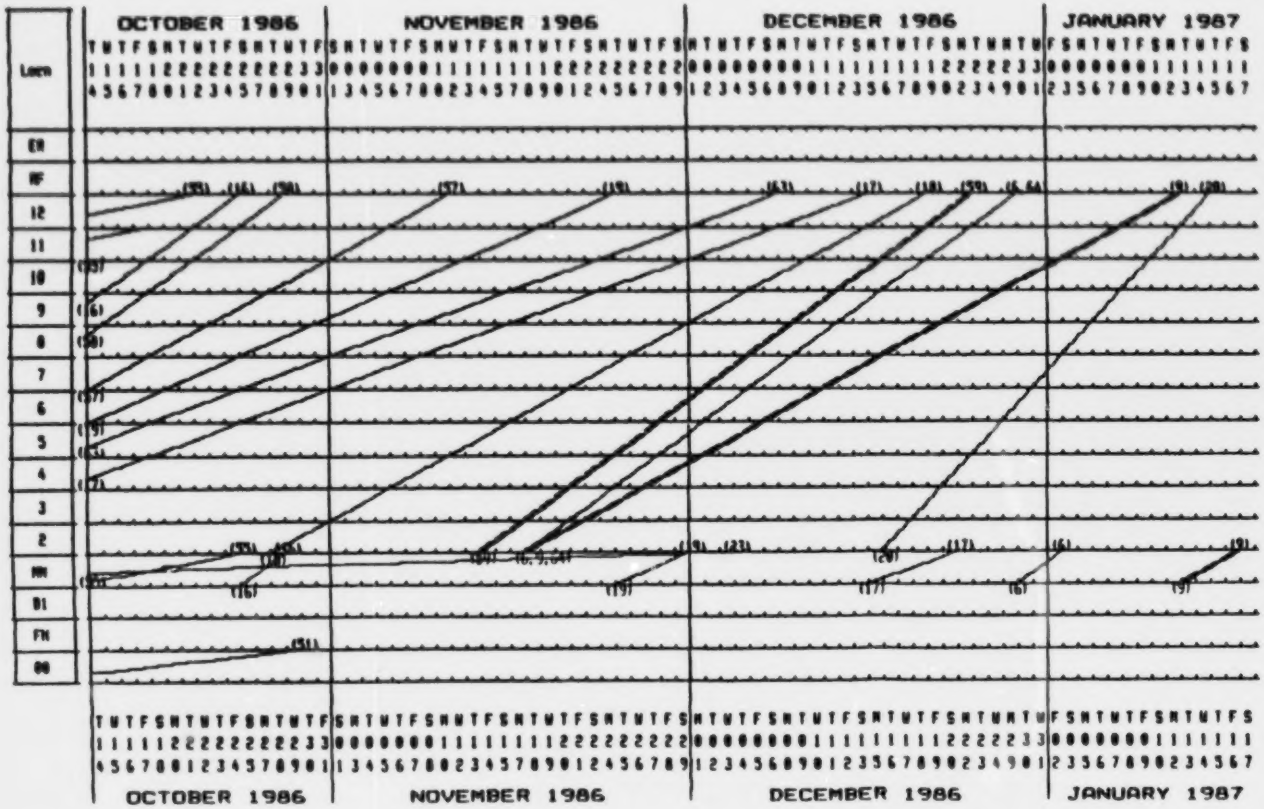
APARTMENT BUILDING

LINEAR PLANNING CHART

R | * critical act.
E | @ act. behind sch.
Y | p act. has procurement seq.
| c completed

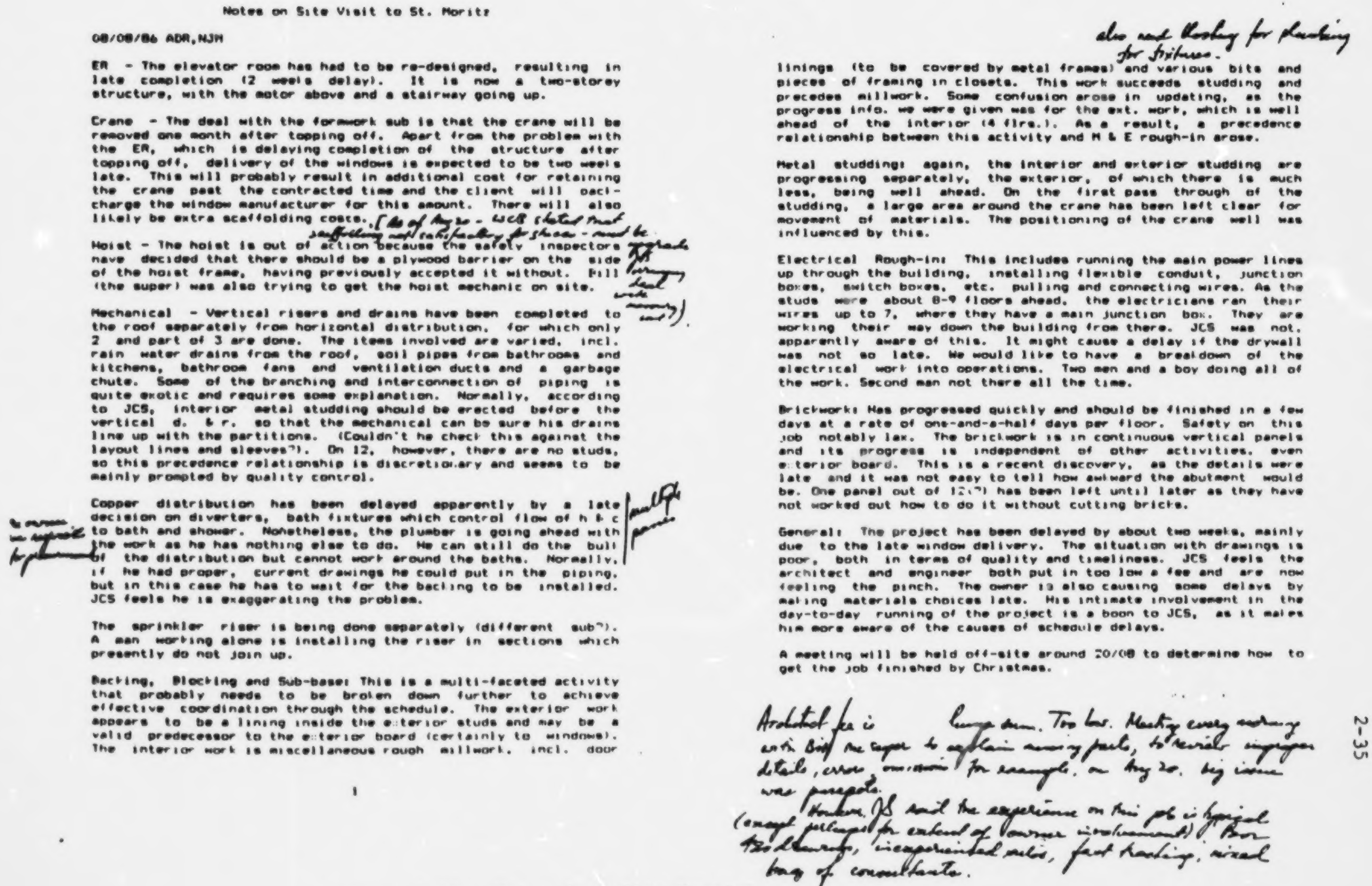
Report Date : 1986-07-30
Report Time : 13:04:00

File Used : C:\DATAFIL\.
Progress as of : 1986-07-24
Revision Number : 0
Window Schedule :
From 6JAN86 To 31JAN87
From FN To ER



ACTIVITY KEY
Act No Act Description
(6) 060300 ELECTRICAL FINISHING
*(9) 070300 PLUMBING FINISHING
(16) 160100 PAINT 2 PRIMER COATS
(17) 160200 PAINT FINISH / TRIM
(18) 170100 KITCHN & BATHRM CABTS
(19) 180100 DOORS & HARDWARE
(20) 190100 CARPETING
(23) 012300 LANDSCAPING
(51) 142400 ELEV DOORS & CABS
(55) 090500 TAPE AND FILL
(57) 200100 BATHROOM MARBLE
(58) 210100 WOOD FLOORS KITCHEN
*(59) 210200 FINISH KITCHEN FLOOR
(63) 010200 MILLWORK
(64) 220100 INSTALL KITCHEN APPL

Figure 2-14 (cont'd)



Notes on Site Visit to St. Moritz

08/08/86 ADR,NJM

ER - The elevator room has had to be re-designed, resulting in late completion (2 weeks delay). It is now a two-storey structure, with the motor above and a stairway going up.

Crane - The deal with the formwork sub is that the crane will be removed one month after topping off. Apart from the problem with the ER, which is delaying completion of the structure after topping off, delivery of the windows is expected to be two weeks late. This will probably result in additional cost for retaining the crane past the contracted time and the client will back-charge the window manufacturer for this amount. There will also likely be extra scaffolding costs. [As of Aug 20 - WCB stated that scaffolding not satisfactory for shear - must be upgraded. [illegible] money [illegible])

Hoist - The hoist is out of action because the safety inspectors have decided that there should be a plywood barrier on the side of the hoist frame, having previously accepted it without. Bill (the super) was also trying to get the hoist mechanic on site.

Mechanical - Vertical risers and drains have been completed to the roof separately from horizontal distribution, for which only 2 and part of 3 are done. The items involved are varied, incl. rain water drains from the roof, soil pipes from bathrooms and kitchens, bathroom fans and ventilation ducts and a garbage chute. Some of the branching and interconnection of piping is quite exotic and requires some explanation. Normally, according to JCS, interior metal studding should be erected before the vertical d. & r. so that the mechanical can be sure his drains line up with the partitions. (Couldn't he check this against the layout lines and sleeves?). On 12, however, there are no studs, so this precedence relationship is discretionary and seems to be mainly prompted by quality control.

Copper distribution has been delayed apparently by a late decision on diverters, bath fixtures which control flow of h & c to bath and shower. Nonetheless, the plumber is going ahead with the work as he has nothing else to do. He can still do the bulk of the distribution but cannot work around the baths. Normally, if he had proper, current drawings he could put in the piping, but in this case he has to wait for the backing to be installed. JCS feels he is exaggerating the problem.

to overcome [illegible] for plumbing

multiple [illegible]

The sprinkler riser is being done separately (different sub?). A man working alone is installing the riser in sections which presently do not join up.

Backing, Blocking and Sub-base: This is a multi-faceted activity that probably needs to be broken down further to achieve effective coordination through the schedule. The exterior work appears to be a lining inside the exterior studs and may be a valid predecessor to the exterior board (certainly to windows). The interior work is miscellaneous rough millwork, incl. door linings (to be covered by metal frames) and various bits and pieces of framing in closets. This work succeeds studding and precedes millwork. Some confusion arose in updating, as the progress info. we were given was for the ext. work, which is well ahead of the interior (4 flrs.). As a result, a precedence relationship between this activity and M & E rough-in arose.

also need blocking for plumbing for fixtures.

Metal studding: again, the interior and exterior studding are progressing separately, the exterior, of which there is much less, being well ahead. On the first pass through of the studding, a large area around the crane has been left clear for movement of materials. The positioning of the crane well was influenced by this.

Electrical Rough-in: This includes running the main power lines up through the building, installing flexible conduit, junction boxes, switch boxes, etc. pulling and connecting wires. As the studs were about 8-9 floors ahead, the electricians ran their wires up to 7, where they have a main junction box. They are working their way down the building from there. JCS was not apparently aware of this. It might cause a delay if the drywall was not so late. We would like to have a breakdown of the electrical work into operations. Two men and a boy doing all of the work. Second man not there all the time.

Brickwork: Has progressed quickly and should be finished in a few days at a rate of one-and-a-half days per floor. Safety on this job notably lax. The brickwork is in continuous vertical panels and its progress is independent of other activities, even exterior board. This is a recent discovery, as the details were late and it was not easy to tell how awkward the abutment would be. One panel out of 12(?) has been left until later as they have not worked out how to do it without cutting bricks.

General: The project has been delayed by about two weeks, mainly due to the late window delivery. The situation with drawings is poor, both in terms of quality and timeliness. JCS feels the architect and engineer both put in too low a fee and are now feeling the pinch. The owner is also causing some delays by making materials choices late. His intimate involvement in the day-to-day running of the project is a boon to JCS, as it makes him more aware of the causes of schedule delays.

A meeting will be held off-site around 20/08 to determine how to get the job finished by Christmas.

Architect fee is lump sum. Too low. Meeting every morning with Bill the super to explain missing parts, to revise improper details, errors, omissions for example, on Aug 20. Big issue was parapets.

However, JS said the experience on this job is typical (except perhaps for extent of owner involvement). Poor [illegible], inexperienced subs, fast tracking, mixed bag of consultants.

Figure 2-15 Notes from Site Meeting.

```
                                                                                                                                    REPCON™

                    APARTMENT BUILDING

                                                                                                                         Page 1 of 3

                                              B A R   C H A R T
                           +------------------------------------------------------------------+
                         K | m milestone        x non-critical activity    * critical activity          |      Report Date      : 1986-09-09
                         E | s start date       o start procurement        # activity behind schedule   |      Report Time      : 12:13:22
                         Y | f finish date      c completed                - float                      |      File Used        : C:\DATAFIL\.
                           +------------------------------------------------------------------+      Progress as of   : 09-04-1986
                                                                                                            Revision Number  : 1

--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                           |86   86    86    86    86  86     86    86   86    86    86   86    86    86    86   86    86    86    86    86    86 86   87    87    87    87    87    87    87    87
NO.    DESCRIPTION         |AUG  AUG   AUG   AUG   SEP SEP    SEP   SEP  SEP   OCT   OCT  OCT   OCT   NOV  NOV   NOV   NOV   DEC   DEC   DEC   DECDEC  JAN   JAN   JAN   JAN   FEB   FEB   FEB   FEB
                           |6    11    18    25    2   8      15    22   29    6     14   20    27    3     10   17    24    1     8     15    22 29   5     12    19    26    2     9     16    23
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                           |        12              |
070200 SANITARY DRAINS     |        SCF             |
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |                 8     9|    10    11    12    MM
060200 ELECTRICAL ROUGH-IN |               SCCCCCSCXXXXFSXXXXFSXXXXFSXXXXFSXXXXF
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           | 11        12           |
090200 PLACE EXT. BOARD    |FSCF       SCF          |
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           | 91011         12     MM|
100100 EXTERIOR BRICKWORK  |SFSFSF         SF     SXXXXXXXXXXXXF
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |           2   3   4   5|  6  7  8  9 10 11 12 MM
110100 WINDOWS             |          SCCFSCCFSCCFSCCFSXFSXFSXFSXFSXFSXFSXFSXF
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |    MM  2  3  4  5  6  8|    9 10 11 12
070400 Plumbing Rough-in   |    SCFSCFSCFSCFSCCSCCSCXXFSXFSXFSXFSXF
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |               MF       |
1321RF ROOF                |               S######################F
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |                    2  4|              9          112
090600 INSULATION / VB     |                   SCFSXXF           SS          SS
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |                        6             7           10
090600 INSULATION / VB     |                      SSXF           S           S
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |                        |MM
142100 ELEVATOR RAILS      |                        |SXXXXXXXXXXXXXXXXXXXXXXF
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |                        |   2  3  4  5  6  7  8  9  10 11 12 MM
150100 STUCCO              |                        |  SXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXFSXF
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
                           |                        |       2     4     6     8    10    12
090400 PLACE GYPSUM BOARD  |                        |      SXXXXFSXXXXFSXXXXFSXXXXFSXXXXFSXXXXF
                           |.   .     .     .     . |  .     .     .     .     .     .    .     .     .     .     .     .     .     .    .     .      .     .     .     .     .     .     .     .
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                           |86   86    86    86    86  86     86    86   86    86    86   86    86    86    86   86    86    86    86    86    86 86   87    87    87    87    87    87    87    87
NO.    DESCRIPTION         |AUG  AUG   AUG   AUG   SEP SEP    SEP   SEP  SEP   OCT   OCT  OCT   OCT   NOV  NOV   NOV   NOV   DEC   DEC   DEC   DECDEC  JAN   JAN   JAN   JAN   FEB   FEB   FEB   FEB
                           |6    11    18    25    2   8      15    22   29    6     14   20    27    3     10   17    24    1     8     15    22 29   5     12    19    26    2     9     16    23
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Figure 2-16 September 4, 1986 Schedule Update.

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                                                                                                                                                                                                                        Page 2 of 3.
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                             |86  86    86    86    86   86    86    86    86    86    86   86    86    86    86   86    86    86    86    86    86 86   87    87    87    87    87    87    87    87
NO.    DESCRIPTION           |AUG AUG   AUG   AUG   SEP  SEP   SEP   SEP   SEP   OCT   OCT  OCT   OCT   NOV   NOV  NOV   NOV   DEC   DEC   DEC   DECDEC  JAN   JAN   JAN   JAN   FEB   FEB   FEB   FEB
                              16  11    18    25    2    8     15    22    29    6     14   20    27    3     10   17    24    1     8     15    22 29   5     12    19    26    2     9     16    23
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                             |                        |          3     5     7     9     11    MM
 090400 PLACE GYPSUM BOARD   |                        |         SIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |             2           6           10
 090500 TAPE AND FILL        |                        |            SIIIIIIIIIIFSIIIIIIIIIIFSIIIIIIIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                3           7           11
 090500 TAPE AND FILL        |                        |               SIIIIIIIIIIFSIIIIIIIIIIFSIIIIIIIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                   4           8           12
 090500 TAPE AND FILL        |                        |                  SIIIIIIIIIIFSIIIIIIIIIIFSIIIIIIIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                      5           9           MM
 090500 TAPE AND FILL        |                        |                     SIIIIIIIIIIFSIIIIIIIIIIFSIIIIIIIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |             MM
 012300 LANDSCAPING          |                        |             SIIIIIIIIIIIIIIIIIIIIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |              00
 012500 REMOVE CRANE         |                        |              S
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                         00
 142200 ELEV MTRS & CONTROLS |                        |                         SIIIIIIIIIIIIIIIIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                          2  3  4  5  6  7  8  9  10 11 12 MM
 160100 PAINT 2 PRIMER COATS |                        |                         SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                             2     3     4     5     6     7     8     9     10    11    12
 010200 MILLWORK             |                        |                            SIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                             2    3    4    5    6    7    8    9    10   11   12   MM
 100100 DOORS & HARDWARE     |                        |                            SIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                             2   3   4   5   6   7   8   9   10  11  12
 200100 BATHROOM MARBLE      |                        |                            SIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                             2  3  4  5  6  7  8  9  10 11 12
 210100 WOOD FLOORS KITCHEN  |                        |                            SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                                   2     3     4     5     6     7     8     9     10    11    12    MM
 160200 PAINT FINISH / TRIM  |                        |                                  SIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                                             00
 142300 PLATFORM & CABLES    |                        |                                             SIIIIIIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                                                         00
 012600 REMOVE HOIST         |                        |                                                         SF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
                             |                        |                                                         00
 142400 ELEV DOORS & CABS    |                        |                                                         SIIIIIIIIIIIIIIIIIIF
                             |.   .     .     .      .|  .     .     .     .     .     .    .     .     .     .    .     .     .     .     .     .  .    .     .     .     .     .     .     .     .
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                             |86  86    86    86    86   86    86    86    86    86    86   86    86    86    86   86    86    86    86    86    86 86   87    87    87    87    87    87    87    87
NO.    DESCRIPTION           |AUG AUG   AUG   AUG   SEP  SEP   SEP   SEP   SEP   OCT   OCT  OCT   OCT   NOV   NOV  NOV   NOV   DEC   DEC   DEC   DECDEC  JAN   JAN   JAN   JAN   FEB   FEB   FEB   FEB
                              16  11    18    25    2    8     15    22    29    6     14   20    27    3     10   17    24    1     8     15    22 29   5     12    19    26    2     9     16    23
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Figure 2-16 (cont'd)

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                                                                                                                                                                     Page 3 of 3.
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                           |86  86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86 86  87   87   87   87   87   87   87   87
NO.    DESCRIPTION         |AUG AUG  AUG  AUG  SEP  SEP  SEP  SEP  SEP  OCT  OCT  OCT  OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DECDEC JAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB
                           16   11   18   25   2    8    15   22   29   6    14   20   27   3    10   17   24   1    8    15   22 29  5    12   19   26   2    9    16   23
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                           |                     |                                                    2   3   4   5   6   7   8   9   10  11  12
170100 KTCHN & BATHRM CABTS|                     |                                                   SIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF
                           |.   .    .    .    . |  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  .   .    .    .    .    .    .    .
                           |                     |                                                                2  3  4  5  6  7  8  9  10 11 12
210200 FINISH KITCHEN FLOOR|                     |                                                               S*FSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                           |.   .    .    .    . |  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  .   .    .    .    .    .    .    .
                           |                     |                                                                   2  3  4  5  6  7  8  9  10 11 12 MM
060300 ELECTRICAL FINISHING|                     |                                                                  SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                           |.   .    .    .    . |  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  .   .    .    .    .    .    .    .
                           |                     |                                                                   2   3   4   5   6   7   8   9   10  11  12  MM
*070300 PLUMBING FINISHING |                     |                                                                  S**FS**FS**FS**FS**FS**FS**FS**FS**FS**FS**FS**F
                           |.   .    .    .    . |  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  .   .    .    .    .    .    .    .
                           |                     |                                                                   2  3  4  5  6  7  8  9  10 11 12
220100 INSTALL KITCHEN APPL|                     |                                                                  SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                           |.   .    .    .    . |  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  .   .    .    .    .    .    .    .
                           |                     |                                                                                      2 3 4 5 6 7 8 9101112
190100 CARPETING           |                     |                                                                                     SFSFSFSFSFSFSFSFSFSFSF
                           |.   .    .    .    . |  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  .   .    .    .    .    .    .    .
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                           |86  86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86   86 86  87   87   87   87   87   87   87   87
NO.    DESCRIPTION         |AUG AUG  AUG  AUG  SEP  SEP  SEP  SEP  SEP  OCT  OCT  OCT  OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DECDEC JAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB
                           16   11   18   25   2    8    15   22   29   6    14   20   27   3    10   17   24   1    8    15   22 29  5    12   19   26   2    9    16   23
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Figure 2-16 (cont'd)

Instructions on use of the work location report were provided (figure 2-17) along with a work location report for the time window of September 4 to September 24 (figure 2-18). A short cycle schedule and progress chart in matrix format was also provided (figure 2-19). Considerable efforts were now being expended to get BJ to record progress information.

September 24, 1986 Update

The schedule was updated as of September 24, 1986 and is shown in the linear planning chart in figure 2-20. Project completion was now projected to be February 19, 1987. Also provided to JS and BJ were updated bar charts, work location reports and matrix short cycle reports. See October 1, 1986 memo that accompanied the schedule update in figure 2-21. Note item 7 where reference is made to lack of feedback from the site.

October 15, 1986 Site Visit & Meeting with JS

In a discussion with JS, he stated that they were crashing the job to pick up time. He claims that at least 2 months have been lost due to procurement problems. Attributes these problems to slow decision making by the owner.

JS feels that time can be made up by changing logic of remaining finishing activities. He is optimistic that this can be done and that a lot of time has been picked up during the last three weeks.

In order to control his costs, the drywall subcontractor had split up his work and assigned the dropped ceiling and valence work in the bathrooms to a sub-sub trade on a piece work basis. This work was lagging far behind other drywall work. At this time, the drywaller had a crew of 3 and each floor was taking 3-4 days for boarding, exclusive of bathroom work and the front of the building where the crane was located. The drywaller was insisting on continuity of work before he would man up.

The sequence of work was to be: place gypsum board --> ceilings --> tape and fill --> bathroom ceilings --> paint primer coat.

Hardware had not yet been selected for bathrooms by owner. This was delaying bathroom boarding. Claim was that he had lost 3 weeks waiting for hardware plus 1 week because of hardware deficiencies.

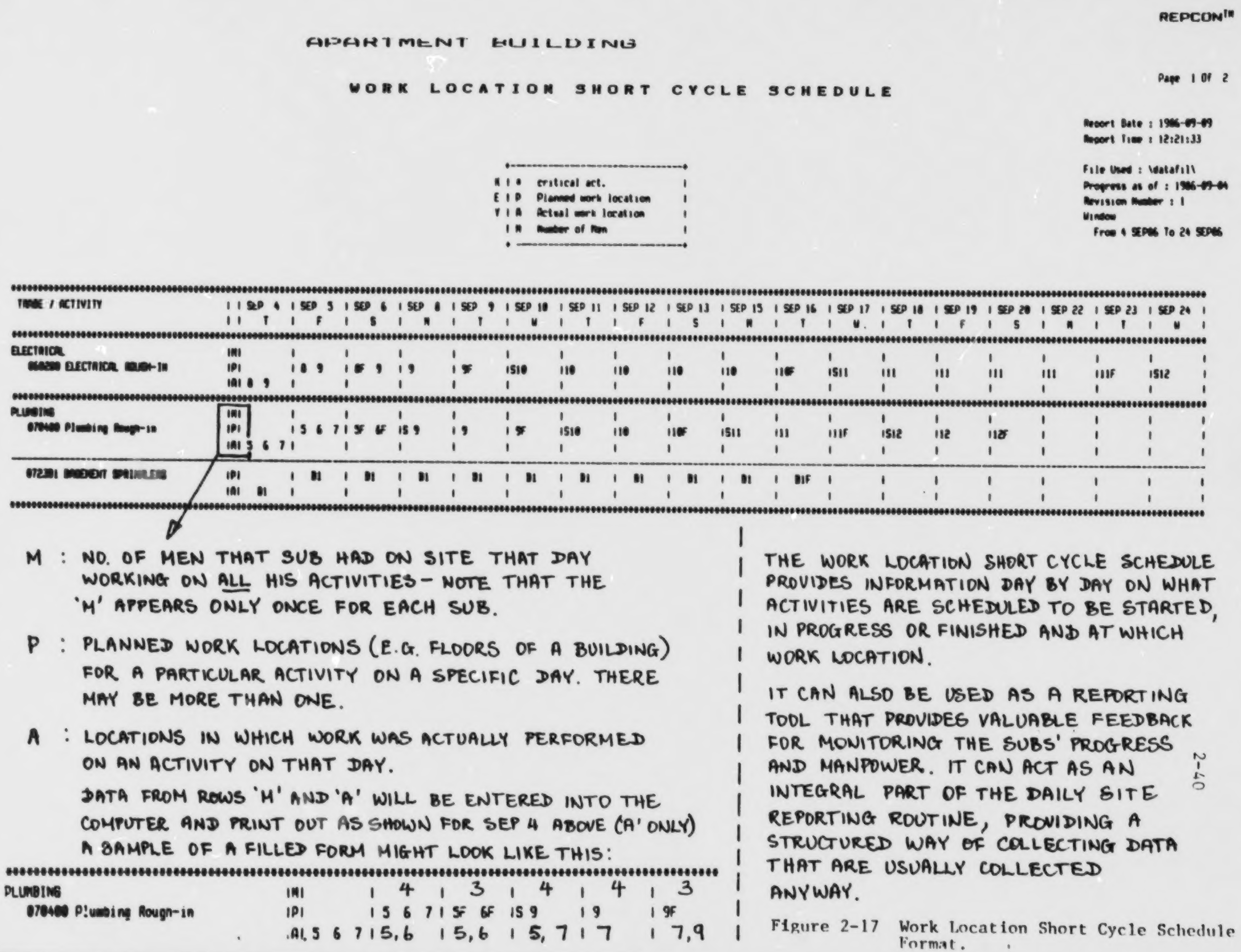
Plumber has washed his hands of the whole process as he can't finish his work.

A preferred sequence was to have the building dry before start of boarding i.e. roof should be sealed, skylights installed, and stucco and caulking completed. However, for this project, boarding was proceeding even though these preferred predecessor were still in progress.

Boarding would continue until the 7th floor and then drop down to the 2nd floor to pick up the crane bay.

Tape and fill had not started. A new estimate of the production rate was 10 days/flr, even with a fast curing compound. Heat would be required and propane blowers could not be used because they would turn everything yellow. Electric heaters would be employed and it was important to have permanent power installed in order to save money.

In a discussion with the electrical subcontractor, he asserted very strongly that the crane had been located incorrectly - right in the middle of where an internal wall was to be placed. This resulted in an additional rough-in pass for all the subtrades. Also, removal of the crane would result in some rework.



REPCON™

APARTMENT BUILDING

WORK LOCATION SHORT CYCLE SCHEDULE

Page 1 Of 2

Report Date : 1986-09-09
Report Time : 12:21:33

File Used : \datafil\
Progress as of : 1986-09-04
Revision Number : 1
Window
From 4 SEP86 To 24 SEP86

K		
E	*	critical act.
Y	P	Planned work location
	A	Actual work location
	M	Number of Men

TRADE / ACTIVITY		SEP 4 T	SEP 5 F	SEP 6 S	SEP 8 M	SEP 9 T	SEP 10 W	SEP 11 T	SEP 12 F	SEP 13 S	SEP 15 M	SEP 16 T	SEP 17 W	SEP 18 T	SEP 19 F	SEP 20 S	SEP 22 M	SEP 23 T	SEP 24 W
ELECTRICAL	M																		
060200 ELECTRICAL ROUGH-IN	P		8 9	8F 9	9	9F	S10	10	10	10	10	10F	S11	11	11	11	11	11F	S12
	A	8 9																	
PLUMBING	M																		
070400 Plumbing Rough-in	P		5 6 7	5F 6F	S 9	9	9F	S10	10	10F	S11	11	11F	S12	12	12F			
	A	5 6 7																	
072301 BASEMENT SPRINKLERS	P		B1	B1	B1	B1	B1	B1	B1	B1	B1	B1F							
	A	B1																	

M : NO. OF MEN THAT SUB HAD ON SITE THAT DAY WORKING ON ALL HIS ACTIVITIES - NOTE THAT THE 'M' APPEARS ONLY ONCE FOR EACH SUB.

P : PLANNED WORK LOCATIONS (E.G. FLOORS OF A BUILDING) FOR A PARTICULAR ACTIVITY ON A SPECIFIC DAY. THERE MAY BE MORE THAN ONE.

A : LOCATIONS IN WHICH WORK WAS ACTUALLY PERFORMED ON AN ACTIVITY ON THAT DAY.

DATA FROM ROWS 'M' AND 'A' WILL BE ENTERED INTO THE COMPUTER AND PRINT OUT AS SHOWN FOR SEP 4 ABOVE ('A' ONLY) A SAMPLE OF A FILLED FORM MIGHT LOOK LIKE THIS:

PLUMBING	M		4	3	4	4	3
070400 Plumbing Rough-in	P		5 6 7	5F 6F	S 9	9	9F
	A	5 6 7	5,6	5,6	5,7	7	7,9

THE WORK LOCATION SHORT CYCLE SCHEDULE PROVIDES INFORMATION DAY BY DAY ON WHAT ACTIVITIES ARE SCHEDULED TO BE STARTED, IN PROGRESS OR FINISHED AND AT WHICH WORK LOCATION.

IT CAN ALSO BE USED AS A REPORTING TOOL THAT PROVIDES VALUABLE FEEDBACK FOR MONITORING THE SUBS' PROGRESS AND MANPOWER. IT CAN ACT AS AN INTEGRAL PART OF THE DAILY SITE REPORTING ROUTINE, PROVIDING A STRUCTURED WAY OF COLLECTING DATA THAT ARE USUALLY COLLECTED ANYWAY.

Figure 2-17 Work Location Short Cycle Schedule Format.

REPCON™

APARTMENT BUILDING

WORK LOCATION SHORT CYCLE SCHEDULE

Page 1 Of 2

Report Date : 1986-09-09
Report Time : 12:21:33

File Used : \datafil\
Progress as of : 1986-09-04
Revision Number : 1
Window
From 4 SEP86 To 24 SEP86

K | * critical act.
E | P Planned work location
Y | A Actual work location
| M Number of Men

TRADE / ACTIVITY		SEP 4	SEP 5	SEP 6	SEP 8	SEP 9	SEP 10	SEP 11	SEP 12	SEP 13	SEP 15	SEP 16	SEP 17	SEP 18	SEP 19	SEP 20	SEP 22	SEP 23	SEP 24
		T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	M	T	W
~~GRADE~~ G.C.	M																		
0123MN LANDSCAPING	P															SMN	MN	MN	MN
	A																		
012401 BACKFILL & GRADING	P		B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1F				
	A	B1																	
012500 REMOVE CRANE	P																S00F		
	A																		
ELECTRICAL	M																		
060200 ELECTRICAL ROUGH-IN	P		8 9	8F 9	9	9F	S10	10	10	10	10	10F	S11	11	11	11	11	11F	S12
	A	8 9																	
PLUMBING	M																		
070400 Plumbing Rough-in	P		5 6 7	5F 6F	S 9	9	9F	S10	10	10F	S11	11	11F	S12	12	12F			
	A	5 6 7																	
072301 BASEMENT SPRINKLERS	P		B1	B1	B1	B1	B1	B1	B1	B1	B1	B1F							
	A	B1																	
DRYWALL	M																		
090400 PLACE GYPSUM BOARD	P								S 2	2	2	2 S 3	2 3	2F 3	3 S 4	3 4	3F 4	4 S 5	4 5
	A																		
090500 TAPE AND FILL	P														S 2	2	2	2 S 3	2 3
	A																		
090600 INSULATION / VB	P		3F 4F												S 7F S 8F	S 9F			
	A	3 4 5																	
WINDOW	M																		
110100 WINDOWS	P		5F	S 6	6	6F	S 7	7	7F	S 8	8	8F	S 9	9	9F	S10	10	10F	S11
	A	5																	

Figure 2-18 Work Location Short Cycle Schedule.

TRADE / ACTIVITY		SEP 4	SEP 5	SEP 6	SEP 8	SEP 9	SEP 10	SEP 11	SEP 12	SEP 13	SEP 15	SEP 16	SEP 17	SEP 18	SEP 19	SEP 20	SEP 22	SEP 23	SEP 24
		T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	M	T	W
ROOF	R																		
1321RF ROOF	P		RF	RF	RF	RF	RF	RF	RF	RF	RF	RF	RF	RF	RF	RFF			
	A	RF																	
ELEVATOR	R																		
142100 ELEVATOR RAILS	P		500	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	A																		
STUCCO	R																		
150100 STUCCO	P				S 2	2	2F	S 3	3	3F	S 4	4	4F	S 5	5	5F	S 6	6	6F
	A																		

Figure 2-18 (cont'd)

```
                                                                                                   REPCON™
          APARTMENT  BUILDING
                                                                                              Page  2 of  2

                                   S H O R T   C Y C L E
                           S C H E D U L E   A N D   P R O G R E S S   C H A R T
                                       +-----------------+-----------------+         Report Date     : 1986-09-09
                                       | SCHEDULE START  | SCHEDULE FINISH |         Report Time     : 12:17:53
                                     K +-----------------+-----------------+         File Used       : C:\DATAFIL\
                                     E |  ACTUAL START   | ACTUAL FINISH / |         Progress As Of  : 1986-09-04
                                     Y |                 |REMAINING DURATION|        Revision Number : 1
                                       +-----------------+-----------------+         Schedule Window : From 1986-09-04
                                       | S  % supplied   | I  % installed  |                           To   1986-10-04
                                       +-----------------+-----------------+

---------------------------------------------------------------------------------------------------------------------------
|     |                 ||                 ||                 ||                 ||                 ||                 ||                  |
|Level| WINDOWS         || INSULATION / VB || STUCCO          || PLACE GYPSUM BD || TAPE AND FILL   || PAINT 2 PRIMER  ||     Remarks      |
|     |110100           ||090600           ||150100           ||090400           ||090500           ||160100           ||                  |
|     |                 ||                 ||                 ||                 ||                 ||                 ||                  |
| RF  |                 ||                 ||                 ||                 ||                 ||                 ||                  |
|     |                 ||                 ||                 ||                 ||                 ||                 ||                  |
|_____|_________________||_________________||_________________||_________________||_________________||_________________||__________________|
|     | 27SEP86| 30SEP86|| 04OCT86| 04OCT86|| 14OCT86| 16OCT86|| 18OCT86| 24OCT86|| 25OCT86| 07NOV86|| 08NOV86| 12NOV86||                  |
| 12  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                  |
|     |        |        ||        |        ||        |        ||        |        ||        |        ||        |        ||                  |
|_____| I|_____________||_I|______________||_I|______________||_I|______________||_I|______________||_I|______________||__________________|
|     | 24SEP86| 26SEP86|| 03OCT86| 03OCT86|| 09OCT86| 11OCT86|| 15OCT86| 21OCT86|| 22OCT86| 04NOV86|| 05NOV86| 07NOV86||                  |
| 11  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                  |
|     |        |        ||        |        ||        |        ||        |        ||        |        ||        |        ||                  |
|_____| I|_____________||_I|______________||_I|______________||_I|______________||_I|______________||_I|______________||__________________|
|     | 20SEP86| 23SEP86|| 03OCT86| 03OCT86|| 06OCT86| 08OCT86|| 10OCT86| 17OCT86|| 18OCT86| 31OCT86|| 01NOV86| 04NOV86||                  |
| 10  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                  |
|     |        |        ||        |        ||        |        ||        |        ||        |        ||        |        ||                  |
|_____| I|_____________||_I|______________||_I|______________||_I|______________||_I|______________||_I|______________||__________________|
|     | 17SEP86| 19SEP86|| 20SEP86| 20SEP86|| 02OCT86| 04OCT86|| 07OCT86| 14OCT86|| 15OCT86| 28OCT86|| 29OCT86| 31OCT86||                  |
|  9  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                  |
|     |        |        ||        |        ||        |        ||        |        ||        |        ||        |        ||                  |
|_____| I|_____________||_I|______________||_I|______________||_I|______________||_I|______________||_I|______________||__________________|
|     | 13SEP86| 16SEP86|| 19SEP86| 19SEP86|| 29SEP86| 01OCT86|| 03OCT86| 09OCT86|| 10OCT86| 24OCT86|| 25OCT86| 28OCT86||                  |
|  8  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                  |
|     |        |        ||        |        ||        |        ||        |        ||        |        ||        |        ||                  |
|_____| I|_____________||_I|______________||_I|______________||_I|______________||_I|______________||_I|______________||__________________|
|     | 10SEP86| 12SEP86|| 19SEP86| 19SEP86|| 25SEP86| 27SEP86|| 30SEP86| 06OCT86|| 07OCT86| 21OCT86|| 22OCT86| 24OCT86||                  |
|  7  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                  |
|     |        |        ||        |        ||        |        ||        |        ||        |        ||        |        ||                  |
|_____| I|_____________||_I|______________||_I|______________||_I|______________||_I|______________||_I|______________||__________________|
|     | 06SEP86| 09SEP86|| 11SEP86| 11SEP86|| 22SEP86| 24SEP86|| 26SEP86| 02OCT86|| 03OCT86| 17OCT86|| 18OCT86| 21OCT86||                  |
|  6  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                  |
|     |        |        || 03SEP86|        ||        |        ||        |        ||        |        ||        |        ||                  |
|_____| I|_____________||_I|  15__________||_I|______________||_I|______________||_I|______________||_I|______________||__________________|
|     | 21AUG86| 23AUG86|| 28AUG86| 28AUG86|| 18SEP86| 20SEP86|| 23SEP86| 29SEP86|| 30SEP86| 14OCT86|| 15OCT86| 17OCT86||                  |
|  5  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                  |
|     |02SEP86|         || 03SEP86|        ||        |        ||        |        ||        |        ||        |        ||                  |
|_____| I|  00__________||_I|  15__________||_I|______________||_I|______________||_I|______________||_I|______________||__________________|
```

Figure 2-19   Matrix Short Cycle Schedule.

```
-------------------------------------------------------------------------------------------------------------------------------------
|     |                  ||                  ||                  ||                  ||                  ||                  ||                 |
|Level| WINDOWS          || INSULATION / VB  || STUCCO           || PLACE GYPSUM BD  || TAPE AND FILL    || PAINT 2 PRIMER   ||     Remarks     |
|_____|110100____________||090600____________||150100____________||090400____________||090500____________||160100____________||_________________|
|     | 18AUG86| 20AUG86|| 20AUG86| 28AUG86|| 15SEP86| 17SEP86|| 19SEP86| 25SEP86|| 26SEP86| 09OCT86|| 10OCT86| 14OCT86||                 |
|  4  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                 |
|     |_27AUG86| 30AUG86|| 02SEP86|        ||        |        ||        |        ||        |        ||        |        ||                 |
|_____| I| 90           || I| 15           || I|              || I:              || I|              || I|              ||_________________|
|     | 14AUG86| 16AUG86|| 27AUG86| 27AUG86|| 11SEP86| 13SEP86|| 16SEP86| 22SEP86|| 23SEP86| 06OCT86|| 07OCT86| 09OCT86||                 |
|  3  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                 |
|     |_22AUG86| 26AUG86|| 02SEP86|        ||        |        ||        |        ||        |        ||        |        ||                 |
|_____| I. 90           || :. 50           || I:              || I|              || I:              || I|              ||_________________|
|     | 07AUG86| 09AUG86|| 27AUG86| 27AUG86|| 08SEP86| 10SEP86|| 12SEP86| 18SEP86|| 19SEP86| 02OCT86|| 03OCT86| 06OCT86||                 |
|  2  |--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||--------|--------||                 |
|     |_18AUG86| 21AUG86|| 20AUG86| 30AUG86||        |        ||        |        ||        |        ||        |        ||                 |
|_____| I| 90           || I| 85           || I:              || I|              || I|              || I.              ||_________________|
|     | 01OCT86| 03OCT86||                  || 17OCT86| 20OCT86|| 22OCT86| 28OCT86|| 29OCT86| 12NOV86|| 13NOV86| 15NOV86||                 |
| PH  |--------|--------||                  ||--------|--------||--------|--------||--------|--------||--------|--------||                 |
|     |________|________||                  ||________|________||________|________||________|________||________|________||                 |
|_____| I|              ||                  || I|              || I|              || I:              || I|              ||_________________|
|     |                  ||                  ||                  ||                  ||                  ||                  ||                 |
| B1  |                  ||                  ||                  ||                  ||                  ||                  ||                 |
|     |__________________||__________________||__________________||__________________||__________________||__________________||                 |
|_____|                  ||                  ||                  ||                  ||                  ||                  ||_________________|
|     |                  ||                  ||                  ||                  ||                  ||                  ||                 |
| FN  |                  ||                  ||                  ||                  ||                  ||                  ||                 |
|     |__________________||__________________||__________________||__________________||__________________||__________________||                 |
|_____|                  ||                  ||                  ||                  ||                  ||                  ||_________________|
|                                                                                                                                   |
|###################################################################################################################################|
|     |                  ||                  ||                  ||                  ||                  ||                  ||                 |
| 00  |                  ||                  ||                  ||                  ||                  ||                  ||                 |
|     |__________________||__________________||__________________||__________________||__________________||__________________||                 |
|_____|                  ||                  ||                  ||                  ||                  ||                  ||_________________|
```

Figure 2-19 (cont'd)

Ceiling board

REPCON™

APARTMENT BUILDING

LINEAR PLANNING CHART

3 days/flr. Ceiling

K | #	critical act.
E | 0	act. behind sch.
Y | p	act. has procurement seq.
| c	completed

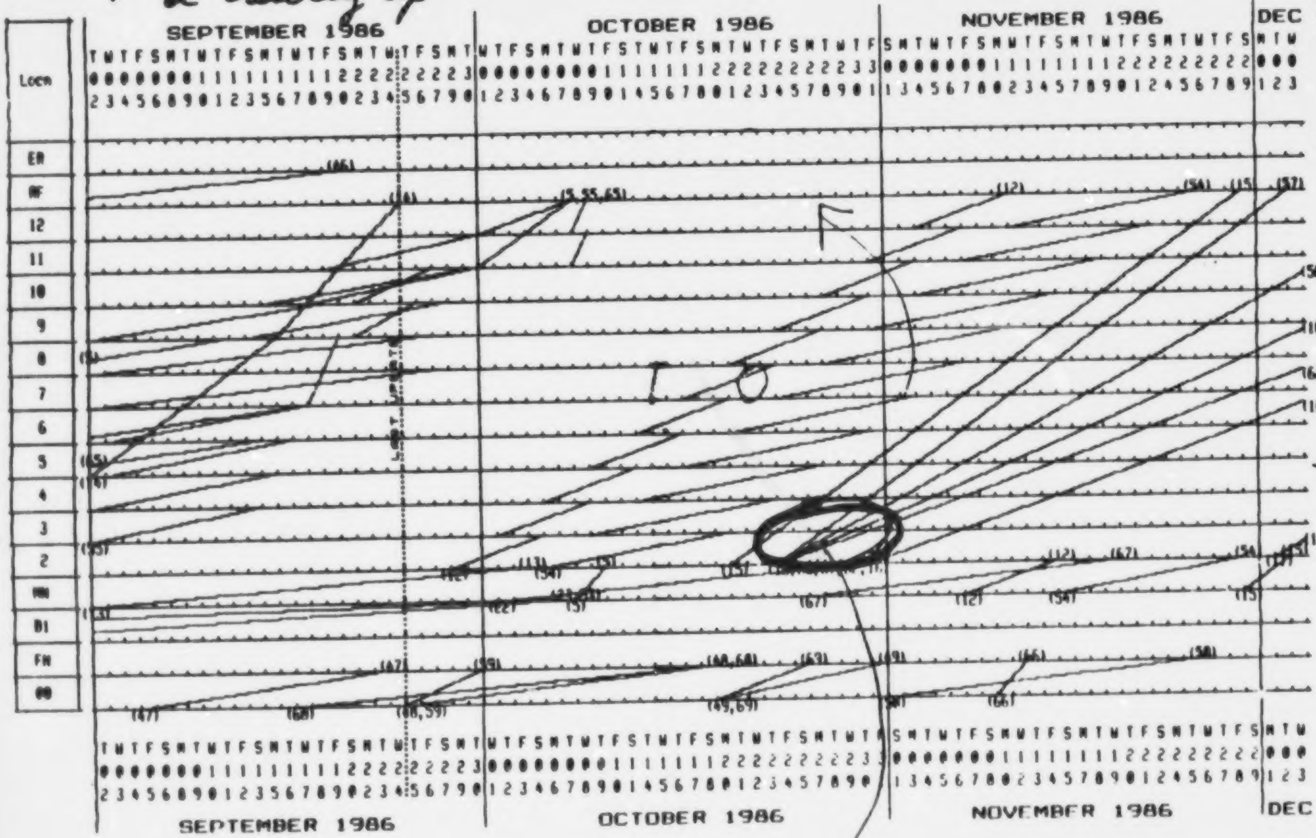
Ceiling material starting Friday Oct 24/86. What has held up is change of materials to ceiling valuates.
Ceiling first, then tape + fill ~~Friday~~
Tape + fill start ~~Friday~~ - will be crewing up

Bathrooms done separately still 5 but 2@'a time

Not feasible to crew up.
2 4 3 5

Report Date : 1986-10-02
Report Time : 12:02:21

File Used : C:\DATAFIL\
Progress as of : 1986-09-24
Revision Number : 1
Window Schedule :
From 25SEP86 To 28FEB87
From FN To ER



Have to go back

Filled in up to 4.

5 days, tape + fill.

Ceiling, 3 days.
- Add as a predecessor to T&F.

ACTIVITY KEY

	Act No	Act Description
#(5)	060200	ELECTRICAL ROUGH-IN
(12)	090400	PLACE GYPSUM BOARD
#(13)	100100	EXTERIOR BRICKWORK
0c(14)	110100	WINDOWS
(15)	160100	PAINT 2 PRIMER COATS
(16)	160200	PAINT FINISH / TRIM
(17)	170100	KTCHN & BATHRM CABTS
(18)	100100	DOORS & HARDWARE
(22)	012300	LANDSCAPING
(23)	012401	BACKFILL & GRADING
c(46)	1321RF	ROOF
c(47)	142100	ELEVATOR RAILS
(48)	142200	ELEV MTRS & CONTROLS
(49)	142300	PLATFORM & CABLES
(50)	142400	ELEV DOORS & CARS
(53)	072301	BASEMENT SPRINKLERS
(54)	090500	TAPE AND FILL
#(55)	090600	INSULATION / VB
* (56)	200100	BATHROOM MARBLE
(57)	210100	WOOD FLOORS KITCHEN
(59)	012500	REMOVE CRANE
(62)	010200	MILLWORK
#(65)	070400	PLUMBING ROUGH-IN
(66)	012600	REMOVE HOIST
(67)	232100	STOREFRONT
(68)	152100	STUCCO
(69)	112100	CAULKING

Figure 2-20 September 24, 1986
Updated Linear Planning
Chart Schedule

IS IT REASONABLE TO EXPECT THAT THESE CAN START ALL AT ONCE.

REPCON™

APARTMENT BUILDING

LINEAR PLANNING CHART

```
+-------------------------------+
K | *  critical act.            |
E | #  act. behind sch.         |
Y | p  act. has procurement seq.|
  | c  completed                |
+-------------------------------+
```

Report Date : 1986-10-02
Report Time : 12:06:34

File Used : C:\DATAFIL\
Progress as of : 1986-09-24
Revision Number : 1
Window Schedule :
From 2SEP86 To 28FEB87
From FN To ER

ACTIVITY KEY

	Act No	Act Description
(6)	060300	ELECTRICAL FINISHING
*(9)	070300	PLUMBING FINISHING
(16)	160200	PAINT FINISH / TRIM
(17)	170100	KTCHN & BATHRM CABTS
(18)	180100	DOORS & HARDWARE
(19)	190100	CARPETING
(56)	200100	BATHROOM MARBLE
*(58)	210200	FINISH KITCHEN FLOOR
(62)	010200	MILLWORK
(63)	220100	INSTALL KITCHEN APPL

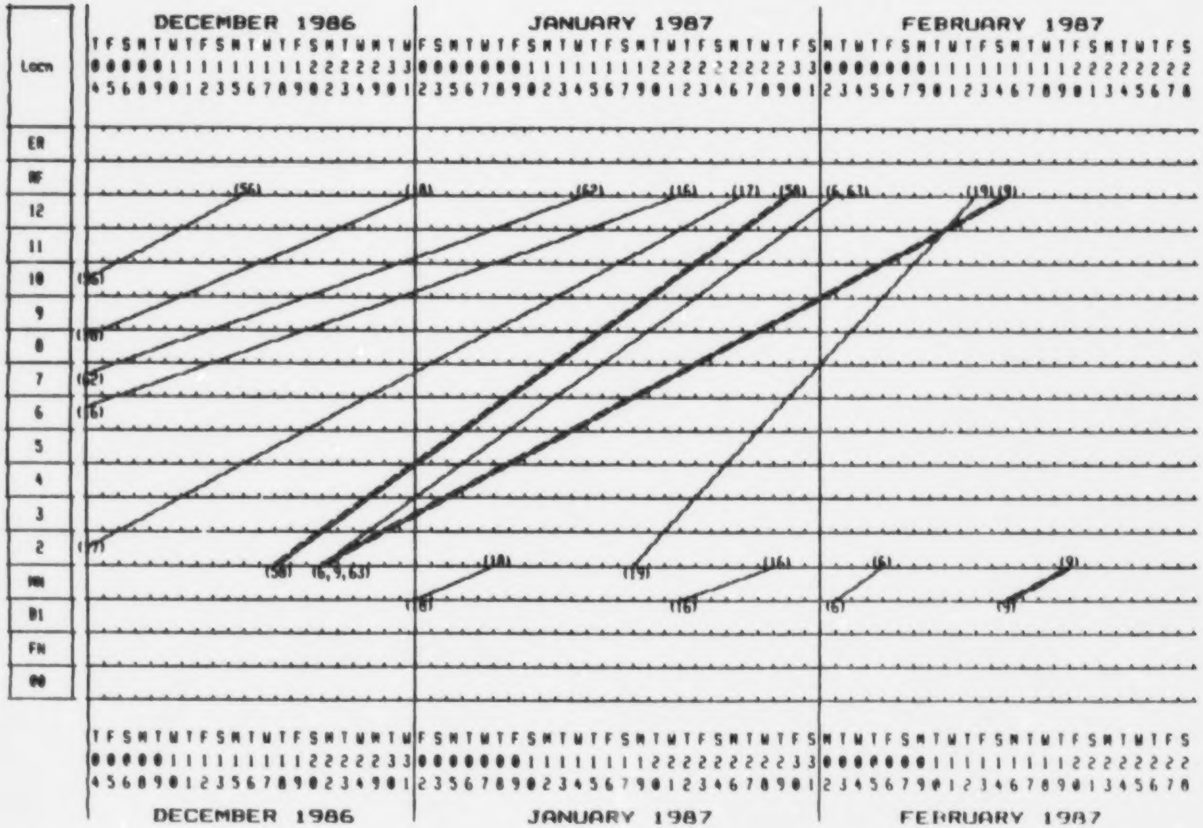


Figure 2-20 (cont'd)

86/10/01

Re: St. Moritz Project Schedule Update

the schedule
does he refer to it??

Dear .

We have completed a schedule update for the St. Moritz Project as of 24SEP86. A variety of outputs is enclosed, all of which are familiar to you. Please note the following regarding the updated schedule:

(1) The forecast project completion date is 19FEB87. The further slippage can be almost totally attributed to the delay in starting the "place gypsum board" activity. As of 30JUL86, we forecasted that this activity would start on 25AUG86. The latest update forecasts a 29SEP86 start.

(2) The project completion date is unaffected by allowing carpeting to be done in parallel with other finishing activities, as its duration is shorter than theirs.

(3) Hoist removal has been kept at 10 NOV86, although the schedule forecasts the elevator platform will be completed on 31OCT86.

(4) Stucco is now a single non-repetitive, as it is difficult to track level by level.

(5) The activity 'storefront" (2321MN) has been added to the schedule. Please check the validity of its start and finish dates, particularly relative to hoist removal.

(6) We are interested in clarifying two areas of interaction among activities:
(a) The cause of the most recent delay in starting the drywall because of the need to complete the bathrooms;
(b) The dependency of landscaping on waterproofing the exterior slabs and completion of the stucco.

(7) Most of the actual dates in the reports are interpolated, as we are not getting detailed feedback from the site.

(8) Obviously, any gains in project duration can be made only through further analysis of the finishing activities. A quick glance at any of the outputs will show that many activities are scheduled to start in the next month (on 24OCT86 especially). It would be worthwhile to spend some time determining how best to go about organising these activities to achieve maximum time compression. We would be happy to work with you on this and make the appropriate revisions to the schedule.

Figure 2-21 Notes Explaining September 24, 1986 Schedule Update.

The electrician was experiencing difficulties in the panel rooms on every third floor. They revolved around the vent shaft and dampers. The dampers had just been chosen and would take 6 weeks for delivery, delaying panel installation.

Exterior enclosure caulking was to be performed using a 2 part Tremco process. Cracks greater than 1/8" width would be filled with styrofoam. The surface would then be wiped down to remove grease to provide a good bond. Caulking would then be applied. From a planning and scheduling viewpoint, these operations can be lumped into one activity. The production rate was estimated to be 3 days per face using a crew of 1-3 people.

Other observations included the following.

> Ceiling work would be done before tape and fill, with a production rate of 3 days/flr.
>
> Fans and lights have to be installed in the bathroom before ceiling board can be applied.
>
> Skylights not yet installed. Installation supposed to start October 15, 1986.
>
> Elevator doors have been set all the way up and masonry around the elevator doors has reached the 12th floor.
>
> Drop ceiling grid starting on ground floor over reflecting pool. This must be completed, including stucco work before reflecting pool can be waterproofed.
>
> Landscaping would involve several operations and trades.
>
> Waterproof membrane --> gravel --> porous fabric --> sand --> soil --> planting.
>
> Permanent power is supposed to be installed soon.

October 22, 1986 Schedule Update

Data collected for October 15 meeting and site visit was used to update the schedule as of October 22, 1986. The updated bar chart is shown in figure 2-22. Project completion is now projected to be March 14/87.

We are not receiving any updating information from BJ.

Provide site with updated work location schedule and matrix report.

October 28, 1986 Site Meeting with JS

JS wants bathroom ceiling drywall work incorporated back into the regular boarding cycle by accelerating the pace and altering logic. Now treating paint primer as an activity that can proceed on any floor as soon as its predecessors are finished. Also, can proceed simultaneously on a number of floors.

These changes were incorporated into the schedule and contributed to a new completion date of February 28, 1986. However, bathroom ceilings never caught up with other boarding work - this was just schedule manipulation to please the owner. It represents an instance where the strategy was to man up through double crewing, but the manpower wasn't available.

Further adjustments were made to this schedule at the request of JS resulting in a revised completion date of February 28, 1986 (figure 2-23). They included a reduction in the duration of painting, simultaneous installation of wood floors with priming, and modification of the logic associated with kitchen and bathroom cabinet installation.

```
                                                                                                  REPCUNM
                         APARTMENT BUILDING

                              Page 1 of 3

                               BAR CHART
                   +-----------------------------------------------------------------+       Report Date      : 1986-10-24
               K   :  m milestone      x non-critical activity   # critical activity        :       Report Time      : 16:36:27
               E   :  s start date     p start procurement       # activity behind schedule :       File Used        : B:\
               Y   :  f finish date    c completed               - float                    :       Progress as of   : 10-22-1986
                   +-----------------------------------------------------------------+       Revision Number  : 1

-----------------------------------------------------------------------------------------------------------------------------------------------------------------------
NO.    DESCRIPTION           :086  86  86  86  86  86  86  86  86  86  86  86  86  86 86 87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87
                             :SSEP SEP OCT OCT OCT OCT NOV NOV NOV NOV DEC DEC DEC DECDEC JAN JAN JAN JAN FEB FEB FEB FEB MAR MAR MAR MAR MAR APR APR APR APR
                             :222  29  6   14  20  27  3   10  17  24  1   8   15  22 29 5   12  19  26  2   9   16  23  2   9   16  23  30  6   13  21  27
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------
                             :                   :          12   MM
060200 ELECTRICAL ROUGH-IN   :CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCIFSIIIIFSF
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :1112               :
110100 WINDOWS               :SFSF               :
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :             11  12:
070400 PLUMBING ROUGH-IN     :CCCCCCCCCCCCCCIIFSCCCFSCCCCCCCCCCIF
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             : 9               12:
090600 INSULATION / VB       : SCCF            SIIIIIIIIIIIIIIIIIIIIIIIIIF
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             : 10            11  :
090600 INSULATION / VB       : SCCCF         SLF :
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :                   :
142100 ELEVATOR RAILS        :IIF                :
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :    00             :
012500 REMOVE CRANE          :    SIIIF          :
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :      2   4   6    :  8   9  10  11  12  MM
090400 PLACE GYPSUM BOARD    :      SCF SCF SCF  : SIIFSIIFSIIFSIIFSIIFSIIF
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :    00             :
142200 ELEV MTRS & CONTROLS: :    SIIIIIIF       :
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :                   :
152100 STUCCO                :IIIIIIIIIIIIIIIIIIIIIIIIF :
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :      MM           :
0123MM LANDSCAPING           :      SII,IIIIIIIIIIIIIIIIIIIIIIIF
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                             :             00    :
112100 CAULKING              :             SIIIIIIIIIIIF
                             :..   .   .   .   . :  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------
NO.    DESCRIPTION           :086  86  86  86  86  86  86  86  86  86  86  86  86  86 86 87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87
                             :SSEP SEP OCT OCT OCT OCT NOV NOV NOV NOV DEC DEC DEC DECDEC JAN JAN JAN JAN FEB FEB FEB FEB MAR MAR MAR MAR MAR APR APR APR APR
                             :222  29  6   14  20  27  3   10  17  24  1   8   15  22 29 5   12  19  26  2   9   16  23  2   9   16  23  30  6   13  21  27
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------
```

Figure 2-22 October 22, 2986 Schedule Update.

[illegible] Start next week.

Being done
THEN DROP CEILINGS

```
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                           :086  86   86   86   86   86   86   86   86   86   86   86   86   86 86 87   87   87   87   87   87   87   87   87   87   87   87   87   87   87   87   87
NO.    DESCRIPTION         :SSEP SEP  OCT  OCT  OCT  OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DECDEC JAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB  MAR  MAR  MAR  MAR  MAR  APR  APR  APR  APR
                           :222  29   6    14   20   27   3    10   17   24   1    8    15   22 29 5    12   19   26   2    9    16   23   2    9    16   23   30   6    13   21   27
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                           :     00               :
142300 PLATFORM & CABLES   :     SIIIIIIIIF       :
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :  2 4 3 5 6 7 8 9 10 11 12 MM
090700 CEILINGS            :                      : SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :   2       3       8       11
090500 TAPE AND FILL       :                      :  SIIIIIF SIIIIIF SIIIIIF SIIIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :      4       6       9       12
090500 TAPE AND FILL       :                      :     SIIIIIF SIIIIIF SIIIIIF SIIIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :         3       7       10      MM
090500 TAPE AND FILL       :                      :        SIIIIIF SIIIIIF SIIIIIF SIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :  MM
2321MM STOREFRONT          :                      :  SIIIIIIIIIIIIIIIIIIF    CHECK [illegible] WHEN CEILING TO START      ( Shop DWGS COMPLETE )
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :              00      :
142400 ELEV DOORS & CABS   :              SIIIIIIIIIIIIIIIIIIIIIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :         2     3     6     8     10    12
090800 BATHROOM CEILINGS   :                      :        SIIIF SIIIF SIIIF SIIIF SIIIF SIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :           4     5     7     9     11    MM
090800 BATHROOM CEILINGS   :                      :          SIIIF SIIIF SIIIF SIIIF SIIIF SIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :              00
012600 REMOVE HOIST        :                      :              SF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :                 2 3 4 5 6 7 8 9 10 11 12 MM
160100 PAINT 2 PRIMER COATS:                      :                SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :                    2     3     4     5     6     7     8     9     10    11    12
010200 MILLWORK            :                      :                   SIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :                    2    3    4    5    6    7    8    9    10   11   12   MM
180100 DOORS & HARDWARE    :                      :                   SIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :                    2   3   4   5   6   7   8   9   10  11  12
260100 BATHROOM MARBLE     :                      :                   SIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :                    2  3  4  5  6  7  8  9  10 11 12
210100 WOOD FLOORS KITCHEN :                      :                   SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :                         2     3     4     5     6     7     8     9     10    11    12    MM
160200 PAINT FINISH / TRIM :                      :                        SIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIFSIIIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                           :                      :                                                2   3   4   5   6   7   8   9   10  11  12
170100 KTCHN & BATHRM CABTS:                      :                                               SIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF
                           :..  .    .    .    .  :  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                           :086  86   86   86   86   86   86   86   86   86   86   86   86   86 86 87   87   87   87   87   87   87   87   87   87   87   87   87   87   87   87   87
NO.    DESCRIPTION         :SSEP SEP, OCT  OCT, OCT  OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DECDEC JAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB  MAR  MAR  MAR  MAR  MAR  APR  APR  APR  APR
```

Figure 2-22 (cont'd)

```
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                              :86  86   86   86   86   86   86   86   86   86   86   86   86   86 86 87   87   87   87   87   87   87   87   87   87   87   87   87   87   87   87   87
NO.   DESCRIPTION             :SSEP SEP  OCT  OCT  OCT  OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DECDEC JAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB  MAR  MAR  MAR  MAR  MAR  APR  APR  APR  APR
                              :22  29   6    14   20   27   3    10   17   24   1    8    15   22 29 5    12   19   26   2    9    16   23   2    9    16   23   30   6    13   21   27
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                              :                        :                                                   2 3 4 5 6 7 8 9 10 11 12
 210200 FINISH KITCHEN FLOOR  :                        :                                                 SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                              :..  .    .    .    .    :    .    .    .    .    .    .    .    .    . .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                              :                        :                                                     2 3 4 5 6 7 8 9 10 11 12 MM
 060300 ELECTRICAL FINISHING  :                        :                                                   SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                              :..  .    .    .    .    :    .    .    .    .    .    .    .    .    . .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                              :                        :                                                     2   3   4   5   6   7   8   9   10  11  12  MM
0070300 PLUMBING FINISHING    :                        :                                                   SIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF
                              :..  .    .    .    .    :    .    .    .    .    .    .    .    .    . .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                              :                        :                                                     2 3 4 5 6 7 8 9 10 11 12
 220100 INSTALL KITCHEN APPL  :                        :                                                   SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF
                              :..  .    .    .    .    :    .    .    .    .    .    .    .    .    . .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                              :                        :                                                                  2 3 4 5 6 7 8 9101112
 190100 CARPETING             :                        :                                                                 SFSFSFSFSFSFSFSFSFSFSF
                              :..  .    .    .    .    :    .    .    .    .    .    .    .    .    . .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                              :86  86   86   86   86   86   86   86   86   86   86   86   86   86 86 87   87   87   87   87   87   87   87   87   87   87   87   87   87   87   87   87
NO.   DESCRIPTION             :SSEP SEP  OCT  OCT  OCT  OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DECDEC JAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB  MAR  MAR  MAR  MAR  MAR  APR  APR  APR  APR
                              :222 29   6    14   20   27   3    10   17   24   1    8    15   22 29 5    12   19   26   2    9    16   23   2    9    16   23   30   6    13   21   27
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
```

Figure 2-22 (cont'd)

```
                                                                                                                REPCON*

                              APARTMENT BUILDING

                                                   Page 1 of 2

                                                     BAR CHART
                                       +-------------------------------------------------------------+      Report Date      : 1986-10-28
                                     K :  @ milestone     x non-critical activity   X critical activity    :      Reprot Time      : 11:38:24
                                     E :  s start date    p start procurement       # activity behind schedule :  File Used        : B:\
                                     Y :  f finish date   c completed               - float                :      Progress as of   : 10-22-1986
                                       +-------------------------------------------------------------+      Revision Number  : 1
---------------------------------------------------------------------------------------------------------------------------
NO.    DESCRIPTION         :86 86  86  86  86  86  86  86  86  86 86 87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87
                           :OCT OCT NOV NOV NOV NOV DEC DEC DEC DECDEC JAN JAN JAN JAN FEB FEB FEB FEB MAR MAR MAR MAR MAR APR APR APR APR
                           :22 27  3   10  17  24  1   8   15  22 29 5   12  19  26  2   9   16  23  2   9   16  23  30  6   13  21  27
---------------------------------------------------------------------------------------------------------------------------
                           ::          12   MM
060200 ELECTRICAL ROUGH-IN :CCCCCCCCCCCXFSXXXXXFSF-----------------------------------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           .: 8  9  10  11  12  MM
090400 PLACE GYPSUM BOARD  :: SXXFSXX/SXXFSXXFSXXFSXXF--------------------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::
152100 STUCCO              ::
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::
0123MM LANDSCAPING         :XXXXXXXXXXF------------------------------------------------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::
112100 CAULKING            :XXXXXF-----------------------------------------------------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::
142300 PLATFORM & CABLES   ::
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           :: 2 4 3 5 6 7 8 9 10 11 12 MM
090700 CEILINGS            :: ##FS#FS#FSXFSXFSXFSXFSXFSXFSXFSXXXXF-----------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::  2       5       8      11
090500 TAPE AND FILL       ::  S#####F  SXXXXXF--SXXXXXF--SXXXXXF-------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::     4       6       9      12
090500 TAPE AND FILL       ::     ######F  SXXXXXF--SXXXXXF--SXXXXXF---------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::       3       7      10      MM
090500 TAPE AND FILL       ::       S#####F  SXXXXXF--SXXXXXF--SXXF------------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::  MM
2321MM STOREFRONT          ::  SXXXXXXXXXXXXXXXXXXXF------------------------------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                           ::
142400 ELEV DOORS & CABS   :XXXXXXXXXXXXXXXXF------------------------------------------------------------
                           :.  .   .   .   .   .   .   .   .   .  .  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
---------------------------------------------------------------------------------------------------------------------------
NO.    DESCRIPTION         :86 86  86  86  86  86  86  86  86  86 86 87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87
                           :OCT OCT NOV NOV NOV NOV DEC DEC DEC DECDEC JAN JAN JAN JAN FEB FEB FEB FEB MAR MAR MAR MAR MAR APR APR APR APR
                           :22 27  3   10  17  24  1   8   15  22 29 5   12  19  26  2   9   16  23  2   9   16  23  30  6   13  21  27
---------------------------------------------------------------------------------------------------------------------------
```

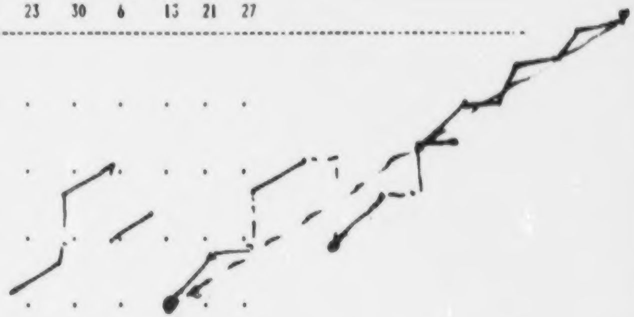
Need inspection

Figure 2-23 Revised October 22, 1986 Schedule Update.

```
--------------------------------------------------------------------------------------------------------------------------------------------------
NO.    DESCRIPTION           :86  86   86   86   86   86   86   86   86   86 86  87   87   87   67   87   87   87   87   87   87   87   87   87   87   87   87   87
                             :OCT OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DECDEC JAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB  MAR  MAR  MAR  MAR  MAR  APR  APR  APR  APR
                             :22  27   3    10   17   24   1    8    15   22 29  5    12   19   26   2    9    16   23   2    9    16   23   30   6    13   21   27
--------------------------------------------------------------------------------------------------------------------------------------------------
                             ::        2    3    6    8    10   12
090800 BATHROOM CEILINGS     ::        S000F S000F SIIIF-SIIIF-SIIIF-SIIIF-----------------------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::          4    5    7    9    11   MM
090600 BATHROOM CEILINGS     ::          S000F SIIIF-SIIIF-SIIIF-SIIIF-SIIIF-----------------------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::              00
012600 REMOVE HOIST          ::              SF-----------------------------------------------------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::              2 4 3 5 6 7 8 9 10 11 12 MM
160100 PAINT PRIMER COAT     ::              SF SF-SF-SF-SF-SF-SF-SF-SF-SF-SF-SF-----------------------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                2    3    4    5    6    7    8    9    10   11   12
801.200 MILLWORK             ::                S0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000F
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                 2   3   4   5   6   7   8   9   10  11  12  MM
180100 DOORS & HARDWARE      ::                 S000FSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIFSIIIF----------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                 2 3 4 5 6 7 8 9 10 11 12
210100 WOOD FLOORS KITCHEN   ::                 SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF-----------------------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                  2   3   4   5   6   7   8   9   10  11  12
170100 KTCHN & BATHRM CABTS  ::                  SIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF-----------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                  2   3   4   5   6   7   8   9   10  11  12
200100 BATHROOM MARBLE       ::                  S00FSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF-----------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                    2    3    4    5    6    7    8    9    10   11   12   MM
8160200 PAINT FINISH / TRIM  ::                    S0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000FS0000F
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                          2 3 4 5 6 7 8 9 10 11 12
210200 FINISH KITCHEN FLOOR  ::                          SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF-------------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                           2 3 4 5 6 7 8 9 10 11 12 MM
060300 ELECTRICAL FINISHING  ::                           SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF---------------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                           2   3   4   5   6   7   8   9   10  11  12  MM
070300 PLUMBING FINISHING    ::                           SIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF----------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                           2 3 4 5 6 7 8 9 10 11 12
220100 INSTALL KITCHEN APPL  ::                           SIFSIFSIFSIFSIFSIFSIFSIFSIFSIFSIF--------------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
                             ::                                        2 3 4 5 6 7 8 9101112
190100 CARPETING             ::                                        SFSFSFSFSFSFSFSFSFSFSF---------------
                             :.   .    .    .    .    .    .    .    .    .  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
--------------------------------------------------------------------------------------------------------------------------------------------------
NO.    DESCRIPTION           :86  86   86   86   86   86   86   86   86   86 86  87   87   87   87   87   87   87   87   87   67   87   87   87   87   87   87   87
                             :OCT OCT  NOV  NOV  NOV  NOV  DEC  DEC  DEC  DECDEC JAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB  MAR  MAR  MAR  MAR  MAR  APR  APR  APR  APR
                             :22  27   3    10   17   24   1    8    15   22 29  5    12   19   26   2    9    16   23   2    9    16   23   30   6    13   21   27
--------------------------------------------------------------------------------------------------------------------------------------------------
```

Possibly November 15.

Connected



Fire Alarm
tie into main
entrance +
Smoke +
heat detectors
(2 weeks to
install +
test out.

Microwaves Coming in December 28
Other Appliances Jan 2. Fridge has
later hookups
(Not Primer — EGG SHELL PAINT)

Figure 2-23 (cont'd)

Makeup:

For Occupancy
Fire Alarm Syst

October 28, 1986 Meeting with JS

Comments noted on bar chart, figure 2-23.

December 17, 1986 Site Visit

Another 2 - 3 weeks of schedule slippage had occurred. Painting and ceiling activities were being undermanned.

Contractor using a check list for suite finishing (see figure 2-4).

December 29, 1986 Site Visit

Substantial difficulties being encountered with bathtub installation resulting in them being ripped out. The factory mould has a flaw and they will not drain properly. A small puddle remains in tub. Tubs being flown back and forth across country.

Ceiling finishing rejected by owner.

Marble from Italy arrived broken.

Kitchen cabinet production/installation too slow.

Quality problems being experienced with drywallers.

Stairwells will be painted as a block activity.

Owner selecting colours as he goes along. He won't provide the painter with a schedule of suite colours. Selecting them one by one, waiting for feedback from potential purchasors viewing show suites.

Also, owner picking marble entrance colours as he goes along.

JS will attempt to get occupancy permit on a floor by floor basis.

December 31, 1986 Schedule Update

Progress was assessed as of December 31, 1986 and the updated schedule produce January 6, 1987. Completion now projected to be April 10/87. Updated linear planning chart shown in figure 2-24.

After review of this schedule by JS, several revisions were made to bring back the completion date to March 30, 1987. This date was further revised to March 21, 1987, including an update to January 7, 1987 (figure 2 - 25). A variety of schedule formats were generated. A small victory, of sorts, occurred. JS continued to monitor progress using the short cycle matrix chart (figure 2 - 26).

At this point, we stopped the experiment. The project dragged on well into April and some outside work was being cleaned up in May.

REPCON™

APARTMENT BUILDING

LINEAR PLANNING CHART

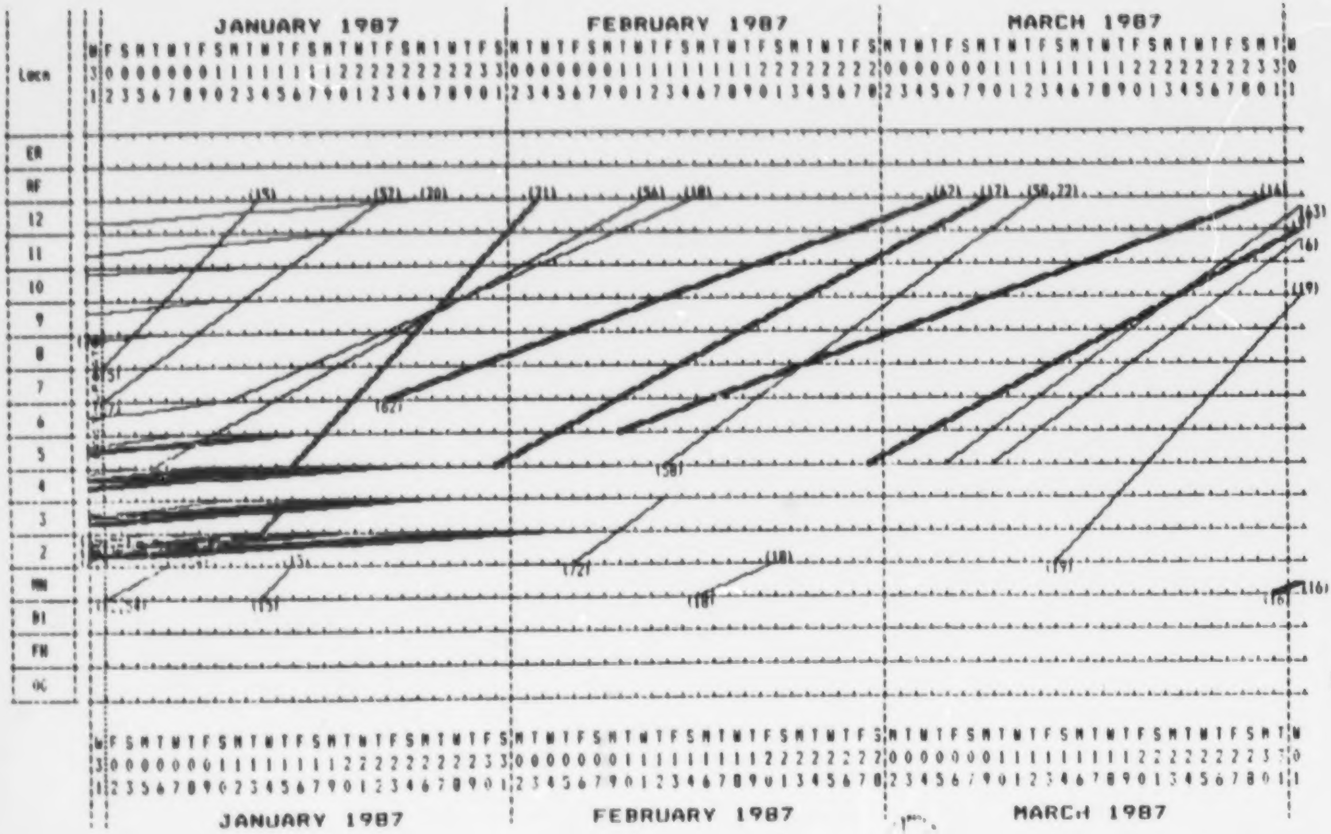
Kitchen/Bath.
3 days/floor.

```
+-----------------------------------+
K : ■  critical act.                :
E : ■  act. behind sch.             :
Y : p  act. has procurement seq.    :
  : c  completed                    :
+-----------------------------------+
```

```
Report Date : 1987-01-06
Report Time : 14:32:10

File Used : B:\REPC2\.

Progress as of : 1986-12-31
Revision Number : 2
Window Schedule :
  From 31DEC86 To 15APR87
  From FN To ER
```



```
ACTIVITY KEY
     Act No Act Description
  ( 6) 060300 ELECTRICAL FINISHING
 ■( 9) 070300 PLUMBING FINISHING
 ■(12) 090400 PLACE GYPSUM BOARD
 ■(15) 160100 PAINT PRIMER COAT
■■(16) 160200 PAINT FINISH / TRIM
■■(17) 170100 KTCHN & BATHRM CABTS
 ■(18) 180100 DOORS & HARDWARE
  (19) 190100 CARPETING
 ■(54) 090500 TAPE AND FILL
 ■(56) 200100 BATHRM FLR/WALL MRBL
 ■(57) 210100 WOOD FLOORS KITCHEN
 ■(58) 210200 FINISH KITCHEN FLOOR
 ■(62) 010200 STE FINISH CARPENTRY
  (63) 220100 KITCHEN APPLIANCES
 ■(70) 090700 CEILINGS
■■(71) 200200 ENTRY FLR. MARBLE
 ■(72) 200300 BATHRM VANITY MARBLE
```

Figure 2-24 December 31, 1986 Schedule Update

REPCON™

APARTMENT BUILDING

LINEAR PLANNING CHART

```
Report Date : 1987-01-06
Report Time : 14:43:03

File Used : B:\REPC2\

Progress as of : 1986-12-31
Revision Number : 2
Window Schedule :
  From 31DEC86 To 15APR87
  From FN To ER
```

```
+------------------------------+
K : #  critical act.           :
E : #  act. behind sch.        :
Y : p  act. has procurement seq. :
  : c  completed               :
+------------------------------+
```

```
ACTIVITY KEY
     Act No Act Description
  ( 6) 060300 ELECTRICAL FINISHING
 #( 9) 070300 PLUMBING FINISHING
##(16) 160200 PAINT FINISH / TRIM
  (19) 190100 CARPETING
  (63) 220100 KITCHEN APPLIANCES
```

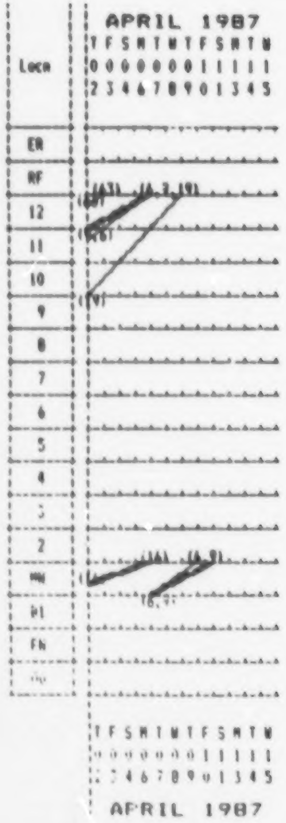


Figure 2-24 (cont'd)

APARTMENT BUILDING

LINEAR PLANNING CHART

REPCON™

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Report Date : 1987-01-08
Report Time : 15:57:05

File Used : D:\REPC2\

Progress as of : 1987-01-07
Revision Number : 2
Window Schedule :
  From 2JAN87 To 30MAR87
  From FN To ER
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+--------------------------------+
K : ●  critical act.             :
E : ●  act. behind sch.          :
f : p  act. has procurement seq. :
  : c  completed                 :
+--------------------------------+
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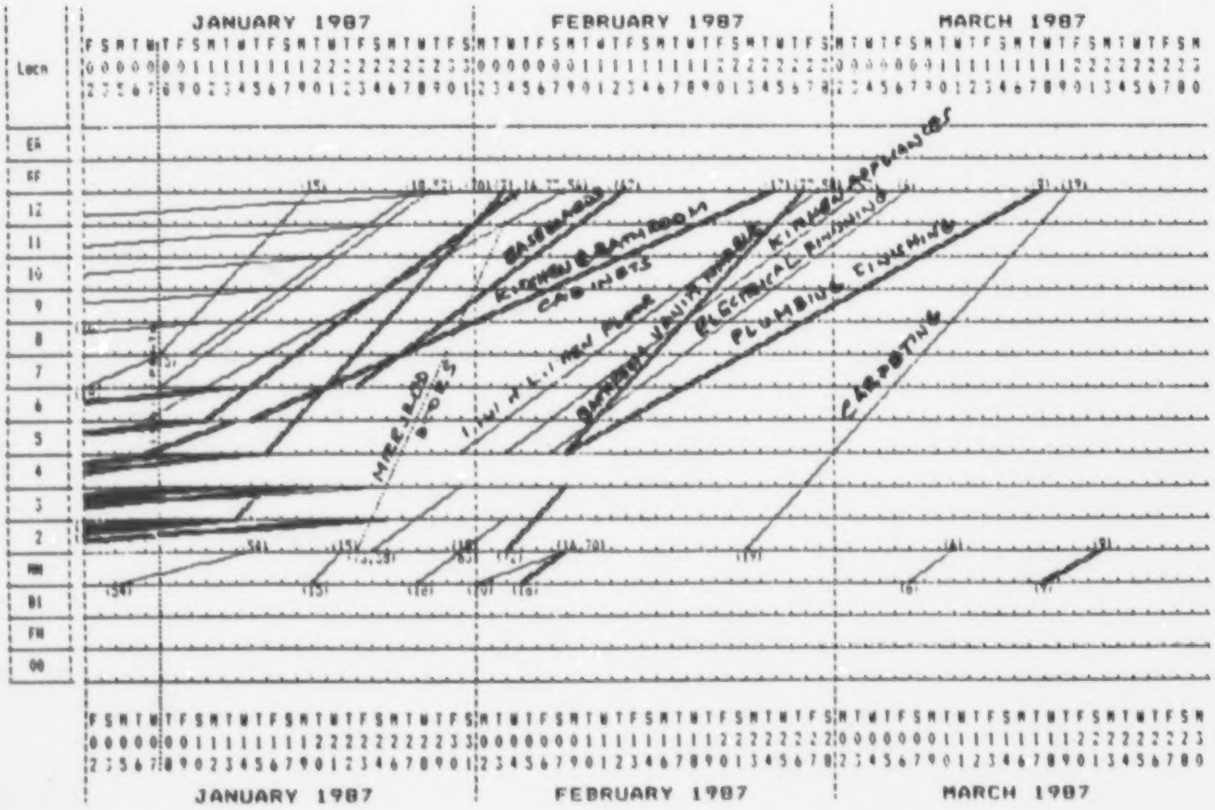
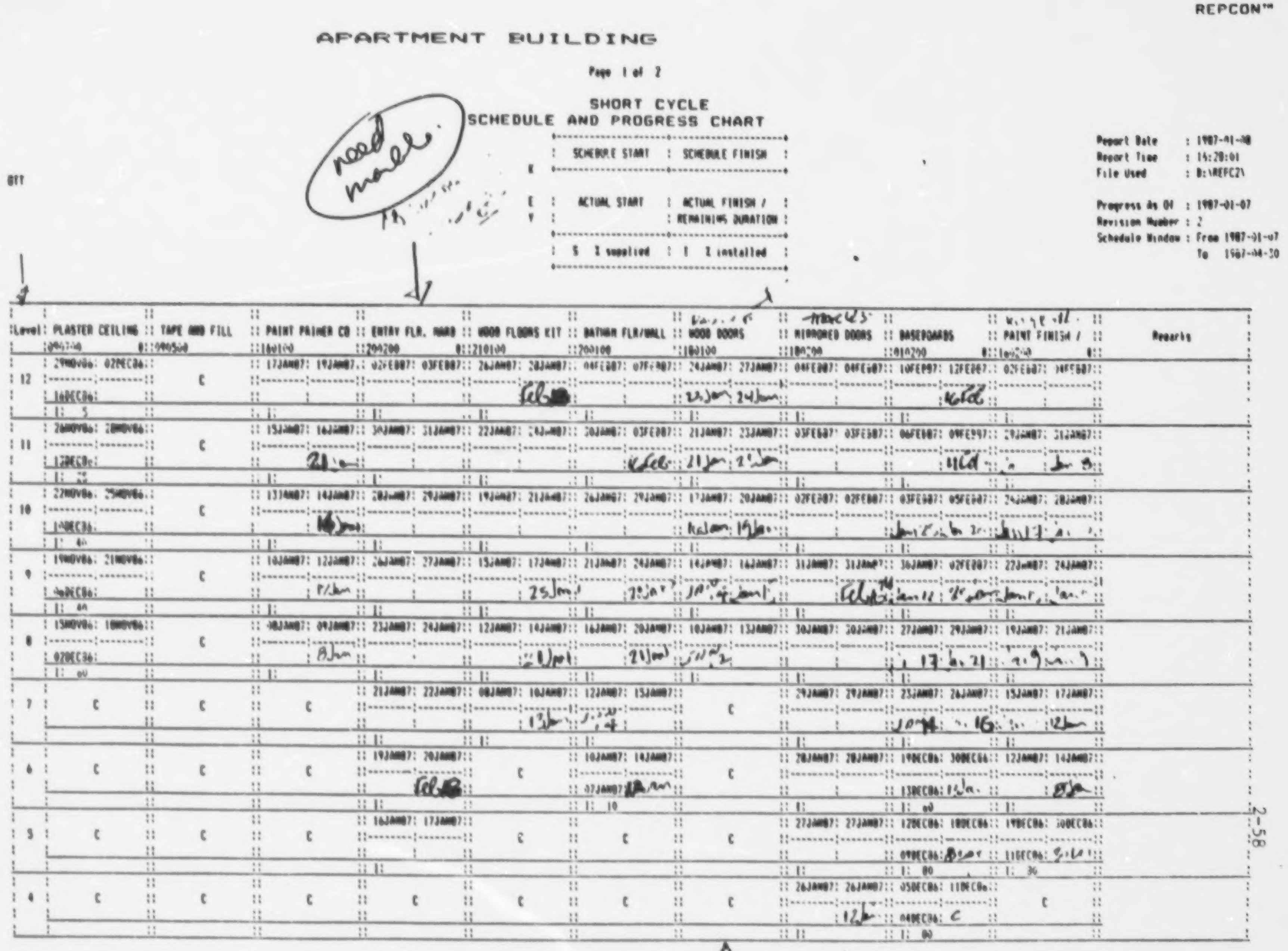


```
ACTIVITY KEY
     Act No Act Description
 ( 6) 060300 ELECTRICAL FINISHING
●( 7) 070300 PLUMBING FINISHING
●(15) 160100 PAINT PRIMER COAT
●●(16) 160200 PAINT FINISH / TRIM
●●(17) 170100 KTCHN & BATHRM CABTS
●(18) 180100 WOOD DOORS
 (19) 190100 CARPETING
●(54) 090500 TAPE AND FILL
●(56) 200100 BATHRM FLR/WALL MRBL
●(57) 210100 WOOD FLOORS KITCHEN
 (58) 210200 FINISH KITCHEN FLOOR
●(62) 010200 BASEBOARDS
 (63) 220100 KITCHEN APPLIANCES
●(70) 090700 PLASTER CEILINGS
●●(71) 200200 ENTRY FLR. MARBLE
●●(72) 200300 BATHRM VANITY MARBLE
 (73) 180200 MIRRORED DOORS
```

Figure 2-25 January 7, 1987 Schedule Update.



REPCON™

APARTMENT BUILDING

Page 1 of 2

SHORT CYCLE
SCHEDULE AND PROGRESS CHART

K E Y		
	SCHEDULE START	SCHEDULE FINISH
	ACTUAL START	ACTUAL FINISH / REMAINING DURATION
	S % supplied	I % installed

Report Date : 1987-01-08
Report Time : 14:28:01
File Used : B:\REPC2\

Progress As Of : 1987-01-07
Revision Number : 2
Schedule Window : From 1987-01-07
To 1987-04-30

Level	PLASTER CEILING 990740	TAPE AND FILL 990500	PAINT PRIMER CO 160100	ENTRY FLR. HARD 200200	WOOD FLOORS KIT 210100	BATHRM FLR/WALL 200100	WOOD DOORS 180100	MIRRORED DOORS 180200	BASEBOARDS 010200	PAINT FINISH / 160240	Remarks
12	29NOV86: 02DEC86 16DEC86: I: 5	C	17JAN87: 19JAN87	02FEB87: 03FEB87	26JAN87: 28JAN87	04FEB87: 07FEB87	24JAN87: 27JAN87 23 Jan: 24 Jan	04FEB87: 04FEB87	10FEB87: 12FEB87	02FEB87: 04FEB87	
11	26NOV86: 28NOV86 12DEC86: I: 22	C	15JAN87: 16JAN87 21 Jan	30JAN87: 31JAN87	22JAN87: 24JAN87	30JAN87: 03FEB87	21JAN87: 23JAN87 21 Jan	03FEB87: 03FEB87	06FEB87: 09FEB87	29JAN87: 31JAN87	
10	22NOV86: 25NOV86 14DEC86: I: 40	C	13JAN87: 14JAN87 16 Jan	28JAN87: 29JAN87	19JAN87: 21JAN87	26JAN87: 29JAN87	17JAN87: 20JAN87	02FEB87: 02FEB87	03FEB87: 05FEB87	24JAN87: 28JAN87	
9	19NOV86: 21NOV86 04DEC86: I: 80	C	10JAN87: 12JAN87	26JAN87: 27JAN87	15JAN87: 17JAN87 25 Jan	21JAN87: 24JAN87	14JAN87: 16JAN87	31JAN87: 31JAN87	30JAN87: 02FEB87	22JAN87: 24JAN87	
8	15NOV86: 18NOV86 02DEC86: I: 00	C	08JAN87: 09JAN87 8 Jan	23JAN87: 24JAN87	12JAN87: 14JAN87	16JAN87: 20JAN87 21 Jan	10JAN87: 13JAN87	30JAN87: 30JAN87	27JAN87: 29JAN87 17 21	19JAN87: 21JAN87	
7	C	C	C	21JAN87: 22JAN87	08JAN87: 10JAN87 13 Jan	12JAN87: 15JAN87	C	29JAN87: 29JAN87	23JAN87: 26JAN87 16	15JAN87: 17JAN87 12 Jan	
6	C	C	C	19JAN87: 20JAN87	C	10JAN87: 14JAN87 07JAN87: I: 10	C	28JAN87: 28JAN87	19DEC86: 30DEC86 13DEC86: I: 00	12JAN87: 14JAN87	
5	C	C	C	16JAN87: 17JAN87	C	C	C	27JAN87: 27JAN87	12DEC86: 18DEC86 09DEC86: I: 80	19DEC86: 30DEC86 11DEC86: I: 36	
4	C	C	C	C	C	C	C	26JAN87: 26JAN87 12 Jan	05DEC86: 11DEC86 04DEC86: C I: 80	C	

Figure 2-26 Contractor's Use of Matrix Schedule.

Page 1 a

Level	PLASTER CEILING 090700	TAPE AND FILL 090500	PAINT PRIMER CO 100100	ENTRY FLR. HARD 200200	WOOD FLOORS KIT 210100	BATHRM FLR/WALL 200100	WOOD DOORS 100100	MIRRORED DOORS 100200	BASEBOARDS 010200	PAINT FINISH / 160200	Remarks
3	C	C	C	14JAN87: 15JAN87	C	C	C	24JAN87: 24JAN87 24 Jan	20NOV86: 04DEC86 27NOV86: 06 Dec 1: 80	05DEC86: 11DEC86 16DEC86: C 1: 70	
2	C	C	C	19NOV86: 20NOV86 11DEC86: 1: 50	C	C	C	23JAN87: 23JAN87 28 Jan	21NOV86: 27NOV86 20NOV86: 27 Nov 1: 60	28NOV86: 04DEC86 08DEC86: C 1: 50	
MB	02FEB87: 07FEB87	02JAN87: 06JAN87 05JAN87: 1: 20	20JAN87: 21JAN87				28JAN87: 30JAN87			05FEB87: 07FEB87	

NOTES:

① BIFOLDS / BI-PASS now going AHEAD. WITHOUT MARBLE ENTRY DOWN BY PUTTING STRIPS UNDER.

② 40 Hours/floor for setting fixtures i [illegible], w/c (11x40 = 440 hours → say $10,000

③ NO PAINT COLOURS FOR SUITES CAUSES PROBLEMS FOR BIFOLDS/BIPASS INSTALLATION

④

Figure 2-26 (cont'd)

...PCON™

APARTMENT BUILDING

Page 2 of 2

SHORT CYCLE
SCHEDULE AND PROGRESS CHART

011

E	SCHEDULE START	SCHEDULE FINISH
E Y	ACTUAL START	ACTUAL FINISH / REMAINING DURATION
	$ % supplied	% installed

Report Date : 1987-01-08
Report Time : 16:29:30
File Used : D:\REPC2\

Progress As Of : 1987-01-07
Revision Number : 2
Schedule Window : From 1987-01-07
To 1987-04-30

the work overlaps on the floors

countop
TOP

Jan 25th in kitchen on 6th floor but not set.

held up need paint colours in corrid. w/ [illegible]

Level	KTCHN & BATHRM 170100	0	BATHRM VANITY R 290300	0	FINISH KITCHEN 210290		KITCHEN APPLIAN 220100		PLUMBING FINISH 070300	0	ELECTRICAL FINI 060300		CARPETING 199100		Remarks
12	19FEB87	24FEB87	25FEB87	26FEB87	25FEB87	27FEB87	20FEB87	03MAR87	13MAR87	17MAR87	04MAR87	06MAR87	18MAR87	19MAR87	
11	13FEB87	18FEB87	23FEB87	24FEB87	21FEB87	24FEB87	25FEB87	27FEB87	09MAR87	12MAR87	28FEB87	03MAR87	16MAR87	17MAR87	[illegible] 11th floor
10	07FEB87	12FEB87	20FEB87	21FEB87	18FEB87	20FEB87	21FEB87	24FEB87	04MAR87	07MAR87	25FEB87	27FEB87	13MAR87	14MAR87	
9	02FEB87	06FEB87	18FEB87	19FEB87	14FEB87	17FEB87	18FEB87	20FEB87	27FEB87	03MAR87	21FEB87	24FEB87	11MAR87	12MAR87	
	23Jan	25Jan	23	26											
8	27JAN87	31JAN87	16FEB87	17FEB87	11FEB87	13FEB87	14FEB87	17FEB87	23FEB87	26FEB87	18FEB87	20FEB87	09MAR87	10MAR87	
	19Jan	22Jan	17	22											
7	21JAN87	26JAN87	13FEB87	14FEB87	07FEB87	10FEB87	11FEB87	13FEB87	18FEB87	21FEB87	14FEB87	17FEB87	06MAR87	07MAR87	
	15Jan	18Jan	15	16											
6	15JAN87	20JAN87	11FEB87	12FEB87	04FEB87	06FEB87	07FEB87	10FEB87	13FEB87	17FEB87	11FEB87	13FEB87	04MAR87	05MAR87	
	10Jan	14Jan	10	14		28Jan				Jan 26					
5	31JAN87	04FEB87	09FEB87	10FEB87	31JAN87	03FEB87	04FEB87	06FEB87	09FEB87	12FEB87	07FEB87	10FEB87	02MAR87	03MAR87	
	07JAN87	9Jan		9		25Jan				Jan [illegible]					
	70														
4	C		08DEC86	10DEC86	C		22JAN87	24JAN87	C		C		27FEB87	28FEB87	
			10DEC86				09DEC86							24Jan	
			50				95								

N.I.C
K.T sink.

Figure 2-26 (cont'd)

started 1/22

Level	KTCHN & BATHRM 170100	BATHRM VANITY M 200300	FINISH KITCHEN 210200	KITCHEN APPLIAN 220100	PLUMBING FINISH 070300	ELECTRICAL FINI 060300	CARPETING 190100	Remarks
3	19NOV86: 22NOV86 02DEC86 75	06FEB87: 07FEB87	28JAN87: 30JAN87 22 Jan	19JAN87: 21JAN87 16DEC86 40	10JAN87: 14JAN87 15DEC86 40	22JAN87: 24JAN87 11DEC86 30	25FEB87: 26FEB87	
2	14NOV86: 18NOV86 09DEC86 75	04FEB87: 05FEB87	26JAN87: 27JAN87 19 Jan	31JAN87: 03FEB87	06JAN87: 09JAN87 13DEC86 40	19JAN87: 21JAN87 13DEC86 90	23FEB87: 24FEB87	
RB					18MAR87: 21MAR87	07MAR87: 10MAR87		

① Started kitchen sinks (els 2-7):
will take two days a floor:
(cold water, hot water, drains!,
disposer, hook ups of dishwashers.

Figure 2-26 (cont'd)

2.4 CASE STUDY TWO

Contributions arising from case study two include:

1) Transfer of the experience gained on case study one to another project and its refinement;
2) Testing and enhancement of another field reporting and updating format; and
3) Testing of the ability of the repetitive planning structures developed under another research program to facilitate rapid updating when location sequences change.

2.4.1 Project Features & Context Information

Initial Schedule

Site work for this project started March 16,1987. No firm completion date was set at the outset, nor was a schedule prepared by the project manager except for tentative floor pour dates. This pour date schedule was never updated. A November 1, 1987 completion date was set later. Substantial completion was achieved by mid-December. Final completion was not achieved until February 1988.

Physical Features

The project was a luxury condominium of 7 strata units on eight floors (2 level penthouse) with initial selling prices ranging from $435000 to $750000 for the penthouse. Each floor contained one 1550 square foot unit. Each unit included two bedrooms, a family room, a luxury kitchen, two bathrooms, one washroom and three balconies. Two underground parking stalls were allocated to each unit.

A one level substructure covered the entire site, which was small, creating problems for storage of materials, including formwork. The reinforced flat plate superstructure covered less than 50% of the substructure. A tower crane was placed outside of the superstructure. No manhoist was used. Walls and columns were formed using gang forms. Slabs were formed using aluminum scaffolding and beams with plywood sheathing. Two sets of slab formwork were available. The structural work started with a crew of 11 men and when the structure was topped out, the crew was down to 6. Of the original crew, only 2 had high-rise experience. An acrylic stucco finish was placed on the exterior. Internal finishes were of above average quality, but not luxurious, at least in comparison to case study one.

Contractual Arrangements & Management Personnel

The firm was retained as a construction manager and entered into a fixed price contract for the structural work.

The project manager, JM, was a product of the trade system in the UK, and had worked as a carpenter in Canada. From there, he had worked his way into management positions. He was quite shy and reserved and was somewhat skeptical about the merits of computerized planning and scheduling. (He has since become a strong supporter of formalized planning and scheduling as well as automated daily site reporting.)

The project superintendent was Bill (BJ) from case study one who stayed with the project until completion of the superstructure. He was then reassigned to start a 19 storey rental high rise project. He was more cooperative on this project and took an interest in explaining construction details to two summer engineering students. He made use of the schedule prepared by the research team (it was the only one he had) and recorded actual progress sporadically.

During his stay on this project, BJ stated his belief that project logic cannot be standardized. He contended that each super does things differently. He shied away from expressing his views on optimal ways of doing work or even preferred ways. He could not articulate why sequences change or how they depend on floor plate size, enclosure and/or finishing details. He maintained a daily diary, but it was of little use in terms of identifying how he viewed project progress. There was no standardization in the use of activity descriptors from day to day.

The second superintendent, Ron (RS), took over in August 1987. He was relatively young, had come up through the ranks as a carpenter and was enthusiastic about the potential for detailed planning and scheduling. He proved to be very cooperative and provided detailed explanations about scoping of finishing cycles. He relied on the schedules provided by the research group and participated in their biweekly updatings, including re-scoping of the project.

Developer

The developer of the project was a contractor who built single family residential housing units.

Research Team Activities

Two summer students assisted ADR in the preparation of the computer schedule starting in May of 1987. One student was supported by the contractor's funds, the other on ADR's research funds. The students were responsible for visiting the site weekly and recording progress in the form of detailed notes. They often discussed progress with BJ, and he took time to verse them in the "realities" of construction. No contact occurred with JM until the fall. Some videotaping of construction cycles was also performed, but it could not be sustained because permission was not forthcoming from adjacent building owners to monitor from their roof level. Starting in late August, ADR took over the tasks of meeting with the new superintendent, RS, and updating the schedule. Frequent meetings were held, largely because of the constant need to alter the schedule to try and bring about a speedy completion of the project.

2.4.2 Summary of the Scheduling/Updating Process

Our experience with this project is summarized in diary form. Where appropriate, only selected schedule formats are shown to reduce the bulk of the report. Emphasis is placed on activity scoping and sequencing and updating, including significant shifts in location sequences.

May 20, 1987 Schedule

A preliminary schedule was prepared and taken to the site for review with BJ. His comments focused on breaking out the structural cycle in some detail as follows:

Day 1: Form columns and walls; insert reinforcing and electrical conduit; place concrete; start stripping slab underneath current one.

Day 2: Strip columns and walls. Start forming next slab, including stairs.

Day 3: Continue forming slab and stairs. Start reinforcing, mechanical sleeving and electrical conduit.

Day 4: Finish forming, reinforcing, sleeving, conduit.

Day 5: Inspect steel, finish up loose ends, pour slab.

Keep Saturday as a buffer.

Other additions focused on parkade sprinklers, fire cabinets and waterproofing.

This feedback was incorporated into the schedule and the bar and linear planning charts shown in figures 2-27 and 2-28 respectively, were produced.

The following comments about these figures are in order.

> Project completion was forecast to be November 6, 1987, although a schedule of finishes had not been completely specified for the project. Also, very little emphasis was placed on site work (e.g. concrete work at grade, planters, retaining walls, driveways, etc). The regulatory process and utility connections were not treated.
>
> BJ did not look far ahead to review rough-in and finishing work. Part of the reason for this was that he knew that he was going to be assigned to another, larger project before completion of this one. Thus, he did not concern himself with scoping of the entire project.
>
> The schedule incorporates some of the learning gained on the first job, particularly the finishing cycle.
>
> The logic or sequencing of the work is not completely refined - several activities are not tied into their proper successors, giving the impression of too much float.
>
> No interest was expressed by the project manager, even though the schedule was left at the site and used on a daily basis by BJ to record progress on the structural work and to provide a guide.
>
> The linear planning chart provides a visual representation of how well production rates were matched. Most of the duration estimates came from the research group, based on experience from other projects, including the first case study. As shown in figure 2-28, the rough-in and finishing location sequence was based on starting at the main floor (MN) and going up through the building to the upper penthouse level, (PU).
>
> A variety of reports were produced for site use, including a matrix short cycle schedule.

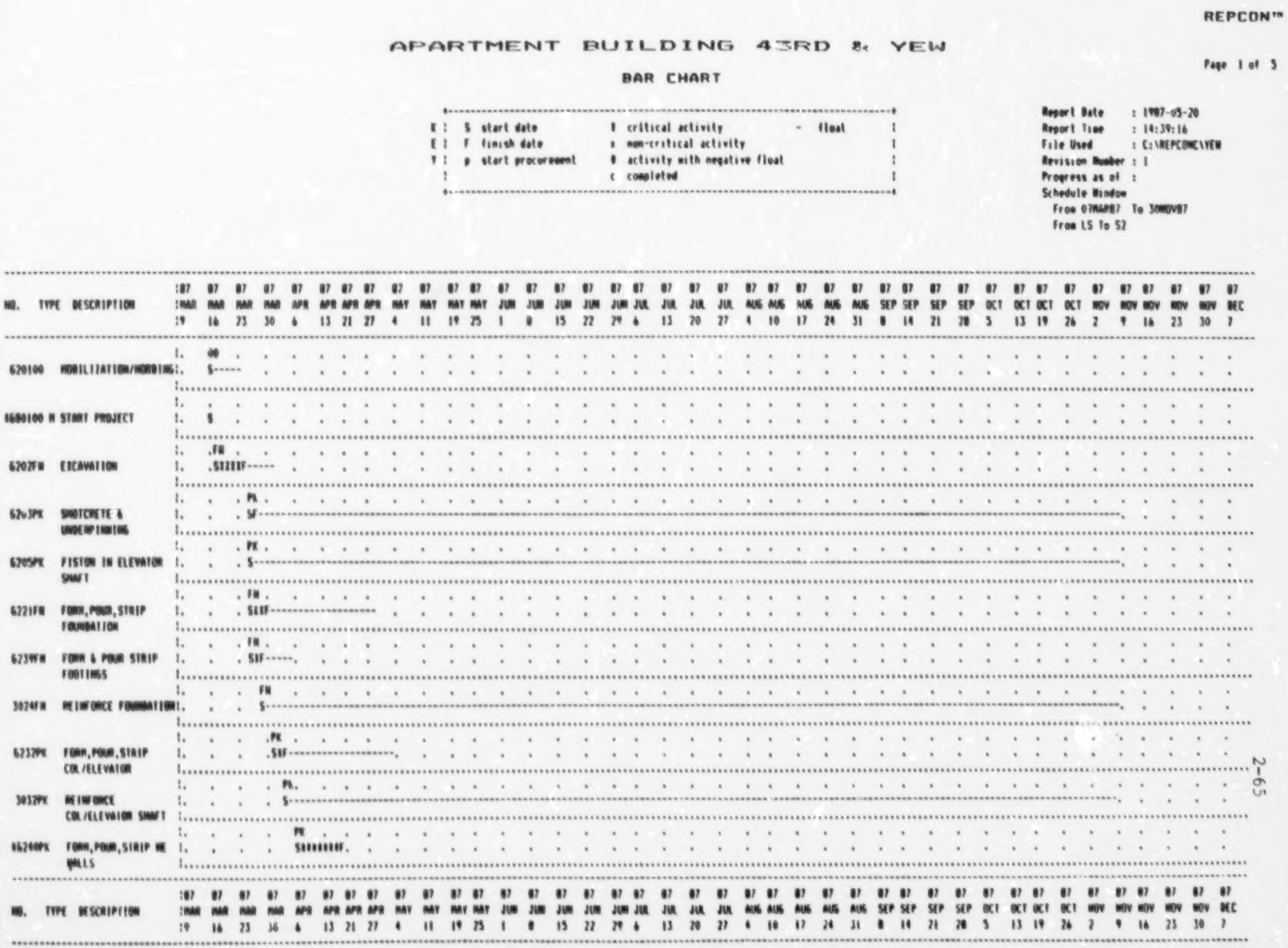
June 26, 1987 Schedule and Previous Update Meetings

This schedule reflected input from two site visits on June 12 and June 18 during which the following observations were made.

Mechanical room and basement sprinkler work were being delayed due to illness on the part of the mechanical subcontractor.

Site constraints necessitated the delay of backfill around the foundation perimeter so forming wall panels could be stored on edge in the excavation.

The topic of work continuity was discussed. For trades responsible for several activities, continuity of crew size was more important to the subtrade than continuity of work on a particular activity. This leads to the notion of buffer activities - e.g. for the electrical subtrade, installation of the electrical room in the basement was a buffer activity when work on other activities could not proceed. For trades that have this kind of work, the general contractor lets the sub organize his own work. For the situation where a trade has one or at most a very few activities, for example the drywall trade, continuity of activity work becomes very important because there is no place to reallocate a crew to if access to work is blocked.



```
                                                                                                                          REPCON™
                         APARTMENT  BUILDING  43RD  &  YEW
                                                                                                                          Page 1 of 5
                                   BAR CHART

              +----------------------------------------------------------------+       Report Date     : 1987-05-20
           K :  S  start date          I  critical activity          -  float  :       Report Time     : 14:39:16
           E :  F  finish date         x  non-critical activity                :       File Used       : C:\REPCONC\YEW
           Y :  p  start procurement   #  activity with negative float         :       Revision Number : 1
             :                         c  completed                            :       Progress as of  :
              +----------------------------------------------------------------+       Schedule Window
                                                                                         From 07MAR87  To 30NOV87
                                                                                         From LS To S2

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                            :07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07
NO.   TYPE  DESCRIPTION     :MAR MAR MAR MAR APR APR APR APR MAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC
                            :9   16  23  30  6   13  21  27  4   11  19  25  1   8   15  22  29  6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7
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                            :.   ##  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
620100  MOBILIZATION/HORDING:.   S-----  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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1680100 M START PROJECT     :.   S   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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                            :.   .FN .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
6202FN  EXCAVATION          :.   .SIIIF------.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                            :.....................................................................................................................................................................
                            :.   .   .   PK  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
6203PK  SHOTCRETE &         :.   .   .   SF----------------------------------------------------------------------------------------------------------------------------.   .   .   .   .
        UNDERPINNING        :.....................................................................................................................................................................
                            :.   .   .   PK  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
6205PK  PISTON IN ELEVATOR  :.   .   .   S-------------------------------------------------------------------------------------------------------------------------------.   .   .   .   .
        SHAFT               :.....................................................................................................................................................................
                            :.   .   .   FN  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
6221FN  FORM,POUR,STRIP     :.   .   .   SIIF----------------.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
        FOUNDATION          :.....................................................................................................................................................................
                            :.   .   .   FN  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
6239FN  FORM & POUR STRIP   :.   .   .   SIF-----.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
        FOOTINGS            :.....................................................................................................................................................................
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3024FN  REINFORCE FOUNDATION:.   .   .   .   S---------------------------------------------------------------------------------------------------------------------------.   .   .   .   .
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6232PK  FORM,POUR,STRIP     :.   .   .   .   .SIF-------------.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
        COL/ELEVATOR        :.....................................................................................................................................................................
                            :.   .   .   .   .   PK. .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
3032PK  REINFORCE           :.   .   .   .   .   S-------------------------------------------------------------------------------------------------------------------.   .   .   .   .
        COL/ELEVATOR SHAFT  :.....................................................................................................................................................................
                            :.   .   .   .   .   PK  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
66240PK FORM,POUR,STRIP HE  :.   .   .   .   .   SIIIIIIIF.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
        WALLS               :.....................................................................................................................................................................
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                            :07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07  07
NO.   TYPE  DESCRIPTION     :MAR MAR MAR MAR APR APR APR APR MAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC
                            :9   16  23  30  6   13  21  27  4   11  19  25  1   8   15  22  29  6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7
..............................................................................................................................................................................................
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Figure 2-27   May 20, 1987 Bar Chart Schedule.

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----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                              :87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87
NO.    TYPE DESCRIPTION       :MAR MAR MAR MAR APR APR APR APR MAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC
                              :9   16  23  30  6   13  21  27  4   11  19  25  1   8   15  22  29  6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7
----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                              :.   .   .   .   .   PK  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 3040PK   REINFORCE NORTH &   :.   .   .   .   .   S-----------------------------------------------------------------------------------------------------------------------.   .   .   .   .
          EAST WALLS          :.................................................................................................................................................................
                              :.   .   .   .   .   PK  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 16250PK  FORM,POUR,STRIP SW  :.   .   .   .   .   S000000000000F. .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          WALLS               :.................................................................................................................................................................
                              :.   .   .   .   .   00  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 212100   ERECTION OF TOWER   :.   .   .   .   .   SF----------------------------------------------------------------------------------------------------------------------.   .   .   .   .
          CRANE               :.................................................................................................................................................................
                              :.   .   .   .   .   .PK .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 3050PK   REINFORCE SOUTH &   :.   .   .   .   .   .S----------------------------------------------------------------------------------------------------------------------.   .   .   .   .
          WEST WALLS          :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   PK  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 06206PK  COMPACTION/FILLING  :.   .   .   .   .   .   .   .   SF  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          OF SUBBASE          :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .PK .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 06355PK  POUR SLAB FOR       :.   .   .   .   .   .   .   .   .S  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          PARKING LEVEL       :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   MM. .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 06356MM  FORM MAIN SLAB      :.   .   .   .   .   .   .   .   .   S000000F.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                              :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .MM .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 03055MM  REINFORCE MAIN SLAB :.   .   .   .   .   .   .   .   .   .S00F   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                              :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   MM. .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 01555MM  PLUMBING SLEEVING   :.   .   .   .   .   .   .   .   .   .   S0F .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          MAIN SLAB           :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   MM. .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 01655MM  ELECT. CONDUITS MAIN:.   .   .   .   .   .   .   .   .   .   S0F .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          SLAB                :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   MM. .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 05155MM  FLOOR VENT. DUCTS   :.   .   .   .   .   .   .   .   .   .   S0F .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          MAIN FLOOR          :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   .   .MM .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 06357MM  PLACE/FINISH MAIN   :.   .   .   .   .   .   .   .   .   .   .   .S  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          SLAB                :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   .   .2 .   .3  .4  .5  .6  .PL . PU .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0160200 P WALL/COL. ELECT.   :.   .   .   .   .   .   .   .   .   .   .   .SF------S---S---S---S---S--. S   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          CONDUITS            :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   .   .2 .   .3  .4  .5  .6  .PL . PU .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0300200 P WALL/COL.          :.   .   .   .   .   .   .   .   .   .   .   .SF------S---S---S---S---S--. S   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          REINFORCEMENT       :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   .   .2 .   .3  .4  .5  .6  .PL . PU .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0610100 N WALL/COL. FORM     :.   .   .   .   .   .   .   .   .   .   .   .SF.   .S  .S  .S  .S  .S  . S   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                              :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   .   . 2  . 3 . 4 . 5 . 6 . PL. PU.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0610000 P SLAB FORMWORK      :.   .   .   .   .   .   .   .   .   .   .   . S000F--S0F--S0F--S0F--S0F--S0F--S0F   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                              :.................................................................................................................................................................
                              :.   .   .   .   .   .   .   .   .   .   .   . 2  . 3 . 4 . 5 . 6 . PL. PU.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 0610200 P WALL/COL. STRIP FORM:.  .   .   .   .   .   .   .   .   .   .   . S------S----S----S----S----S-- S .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
                              :.................................................................................................................................................................
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                              :87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87
NO.    TYPE DESCRIPTION       :MAR MAR MAR MAR APR APR APR APR MAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC
                              :9   16  23  30  6   13  21  27  4   11  19  25  1   8   15  22  29  6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7
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Figure 2-27 (cont'd)

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NO.     TYPE DESCRIPTION         :87  87  87  87  87  87 87 87  87  87  87 87  87  87  87  87  87 87  87  87  87  87 87  87  87  87  87 87  87  87  87  87 87  87  87  87 87  87  87  87
                                 :MAR MAR MAR MAR APR APR APR APR MAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC
                                 :9   16  23  30  6   13 21 27  4   11  19 25  1   8   15  22  29 6   13  20  27  4  10  17  24  31  8  14  21  28  5  13 19  26  2   9  16  23  30  7
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                                 !.   .   .   .   .   .  .  .   .   .   .  . 2 . 3 . 4 . 5 . 6 . PL  PU  .   .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
0300100 P SLAB REINFORCEMENT     !.   .   .   .   .   .  .  .   .   .   .  . SIF---SF---SF---SF---SF---SF---SF  .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .  2 . 3 . 4 . 5 . 6 . PL  PU  .   .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
0150100 P PLUMBING SLEEVING      !.   .   .   .   .   .  .  .   .   .   .  .  SF---SF---SF---SF---SF---SF---SF  .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .  2 . 3 . 4 . 5 . 6 . PL  PU  .   .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
0160100 P ELECTRICAL CONDUITS    !.   .   .   .   .   .  .  .   .   .   .  .  SF---SF---SF---SF---SF---SF---SF  .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .  2 . 3 . 4 . 5 . 6 . PL  PU  .   .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
0510100 P FLOOR VENTILATION      !.   .   .   .   .   .  .  .   .   .   .  .  SF---SF---SF---SF---SF---SF---SF  .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
          DUCTS                  !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   2   3   4   5   6  .PL .PU  .   .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
0611100 P PLACE/FINISH FLOOR     !.   .   .   .   .   .  .  .   .   .   .  .   S---S---S---S---S---S---S   .   .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
          SLAB                   !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .  .PR .   .  .   .   .   .   .   .  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 1560PK   SPRINKLERS IN          !.   .   .   .   .   .  .  .   .   .   .  .   .   .  .SIIIIIIIIIIIIIF--------------------------------------------------------------------------------.   .   .   .
          PARKADE                !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .  . MM.2 3. 4 5 6 .PL PU  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 151100 N PLUMBING RISERS        !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .  . SIFSIFSIFSIFSIFSIFSIFSIF---------  .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .  . MM.2 3. 4 5 6 .PL PU  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 161100 N ELECTRICAL RISERS      !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .  . SIFSIFSIFSIFSIFSIFSIFSIF---------  .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .  . MM.2 3. 4 5 6 .PL PU  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 511100 N VENTILATION RISERS     !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .  . SIFSIFSIFSIFSIFSIFSIFSIF---------  .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .  . MM.2 3. 4 5 6 .PL PU  .   .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 615000 N STUDDING EXTERIOR      !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .  . SIFSIFSIFSIFSIFSIFSIFSIF---------  .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
          WALLS                  !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .MM 2. 3 4 5 .6 PL PU.  .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 750100 N WINDOW FRAMING         !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .SIFSIFSIFSIFSIFSIFSIFSIF---------.  .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .MM 2. 3 4 5 .6 PL PU.  .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 615100 N EXTERIOR STUD          !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .SIFSIFSIFSIFSIFSIFSIFSIF---------.  .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
          SHEATHING              !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .MM 2. 3 4 5 .6 PL PU.  .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 616100 N INTERIOR STUDDING      !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .SIFSIFSIFSIFSIFSIFSIFSIF---------.  .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .   MM 2 3 4 .5 6. PL.PU .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 101000 N EXTERIOR ACRYLIC       !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .   SIFSIFSIFSIFSIFSIFSIFSIF---------------------------- .   .   .  .  .   .   .   .   .   .   .   .
          FINISH                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .   MM 2 3 4 .5 6. PL.PU .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 151500 N PLUMBING               !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .   SIFSIFSIFSIFSIFSIFSIFSIF-------------- .   .   .  .   .   .  .  .   .   .   .   .   .   .   .
          DISTRIBUTION           !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .   MM 2 3 4 .5 6. PL.PU .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 161500 N ELECTRICAL WIRING      !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .   SIFSIFSIFSIFSIFSIFSIFSIF-------------- .   .                                    .   .
                                 !...........................................................................................................................................................
                                 !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .   .   .  MM2 3.4 5 6 PL.  .   .   .   .  .   .   .   .  .  .   .   .   .   .   .   .   .
 151700 N FIRE CABINETS &        !.   .   .   .   .   .  .  .   .   .   .  .   .   .   .   .   .  .   .   .  SFSFSFSFSFSFSF-------------------------------------------------------.   .   .   .
          HOSES                  !...........................................................................................................................................................
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
NO.     TYPE DESCRIPTION         :87  87  87  87  87  87 87 87  87  87  87 87  87  87  87  87  87 87  87  87  87  87 87  87  87  87  87 87  87  87  87  87 87  87  87  87 87  87  87  87
                                 :MAR MAR MAR MAR APR APR APR APR MAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC
                                 :9   16  23  30  6   13 21 27  4   11  19 25  1   8   15  22  29 6   13  20  27  4  10  17  24  31  8  14  21  28  5  13 19  26  2   9  16  23  30  7
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Figure 2-27 (cont'd)

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NO.     TYPE  DESCRIPTION          :87 87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87
                                   :MAR MAR MAR MAR APR APR APR APR MAY MAY MAY MAY JUN JUN JUN JUN JUN JUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC
                                   :9   16  23  30  6   13  21  27  4   11  19  25  1   8   15  22  29  6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                                   :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .MM2 3 4 5.6 PLPU .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
510200 W DRYER AND TOILET          :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .SFSFSFSFSFSFSFSF---------  .   .   .   .   .   .   .   .   .   .   .   .   .   .
         DUCTS                     :......................................................................................................................................................
                                   :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .MM2 3 4 5,6 PLPU .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
710100 W RIGID INSULATION          :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .SFSFSFSFSFSFSFSF---------  .   .   .   .   .   .   .   .   .   .   .   .   .   .
                                   :......................................................................................................................................................
                                   :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .MM2 3 4 5.6 PLPU .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
750200 W WINDOW GLAZING            :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .SFSFSFSFSFSFSFSF------------------ .   .   .   .   .   .   .   .   .   .   .   .
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07222PU  STEEL FRAMING -           :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . S000F   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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740100 W CAULK WINDOWS             :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . SFSFSFSFSFSFSFSF--------------------------------------------------.   .   .
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07221RF  METAL DECKING             :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . SIIIF .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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7373RF   WATERPROOFING EXT.        :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . SIIIF---------------------------------------------.   .   .
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0617100 W INTERIOR INSULATION      :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . SIFSIFSIFSIFSIFSIFSIFSIF .   .   .   .   .   .   .   .   .
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617200 S GYPSUM JOINTS             :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .SIIIIFSIIIIFSIIIIFSIIIIF- .   .   .   .   .   .   .   .
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150300 W PLUMBING FINISHING        :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . SIFSIFSIFSIFSIFSIFSIFSIF---------------.   .   .   .
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0100100 W PAINT PRIMER COAT        :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   SFSFSFSFSFSFSFSF .   .   .   .   .   .   .   .
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0617300 W PLASTER CEILING          :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .SFSFSFSFSFSFSFSF .   .   .   .   .   .   .   .
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0060100 W KITCHEN/BATHROOM         :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   SFSFSFSFSFSFSFSF.  .   .   .   .   .   .   .
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0110100 W CERAMIC TILES            :.   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   SFSFSFSFSFSFSFSF.  .   .   .   .   .   .   .
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Figure 2-27 (cont'd)

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                            !9   16  23  30  6   13  21  27  4   11  19  25  1   8   15  22  29  6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7
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 610100 H HARDWARE FINISHING!.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   SIFSIFSIFSIFSIFSIFSIFSIF------. .   .   .   .   .   .   .   .
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0100200 H PAINT FINISH COAT !.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . S0FS0FS0FS0FS0FS0FS0FS0F .   .   .   .   .   .   .   .
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0160500 H ELECTRICAL FIXTURES!. .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . SFSFSFSFSFSFSFSF. .   .   .   .   .   .   .
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0510500 H VENTILATION       !.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . SFSFSFSFSFSFSFSF. .   .   .   .   .   .   .
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0920100 H CARPETING         !.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  SFSFSFSFSFSFSFSF .   .   .   .   .   .   .
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0619000 H CLEAN APARTMENTS  !.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   . S0FS0FS0FS0FS0FS0FS0FS0F .   .   .   .   .
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0619100 H APARTMENT         !.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   S0FS0FS0FS0FS0FS0FS0FS0F. .   .   .   .
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                            :9   16  23  30  6   13  21  27  4   11  19  25  1   8   15  22  29  6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7
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Figure 2-27 (cont'd)

APARTMENT BUILDING 43RD & YEW

LINEAR PLANNING CHART

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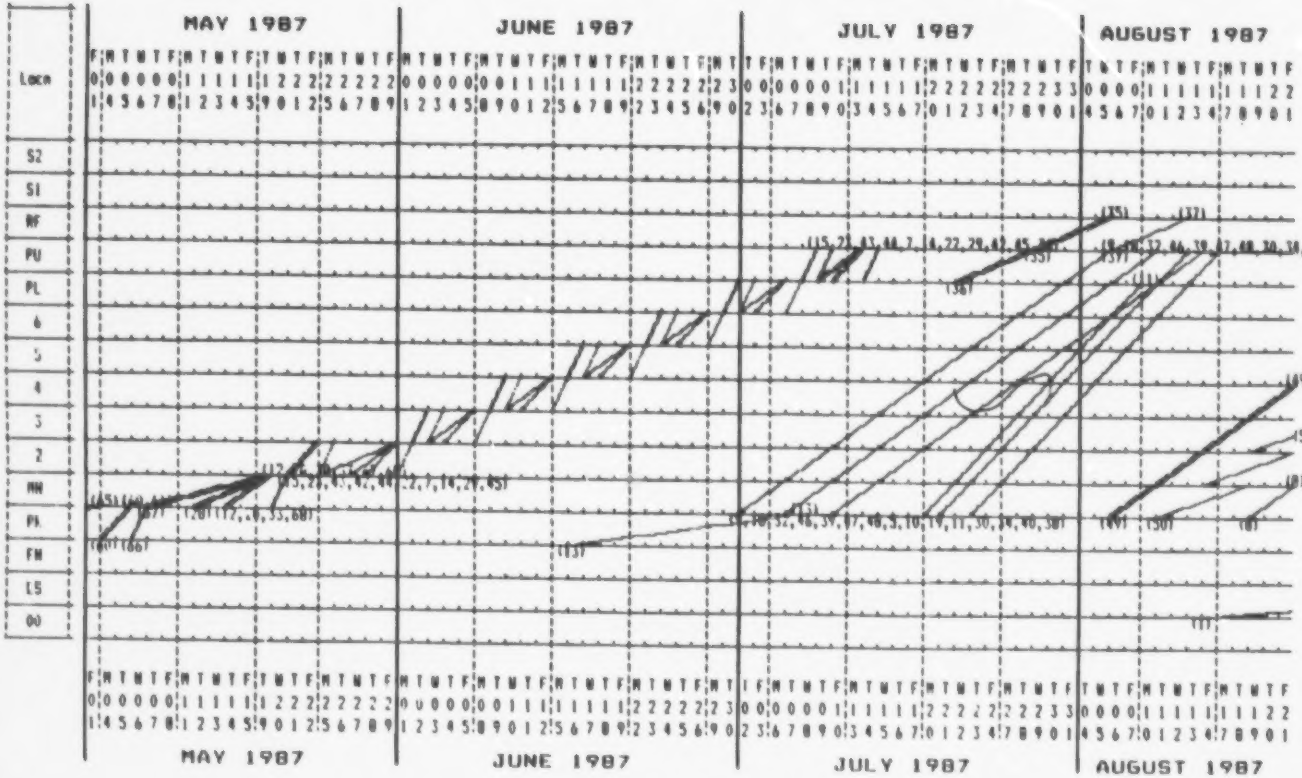
+------------------------------+
K : #  critical act.           !
E : p  act. has procurement seq. !
Y : c  completed               !
+------------------------------+
```

```
Report Date     : 1987-05-20
Report Time     : 14:49:25
File Used       : C:\REPCONC\YEW
Revision Number : 1
Progress as of  :
Schedule Window
  From 01MAY87  To 30NOV87
  From LS To S2
```



```
ACTIVITY KEY
      Act No Type Act Description
 ( 1) 0121LS      LANDSCAPING
 ( 5) 101000  N   EXTERIOR ACRYLIC FINISH
#( 7) 150100  P   PLUMBING SLEEVING
 ( 8) 150300  N   PLUMBING FINISHING
 ( 9) 151100  N   PLUMBING RISERS
 (10) 151500  N   PLUMBING DISTRIBUTION
 (11) 151700  N   FIRE CABINETS & HOSES
#(12) 1555MN      PLUMBING SLEEVING MAIN SLAB
 (13) 1560PK      SPRINKLERS IN PARKADE
#(14) 160100  P   ELECTRICAL CONDUITS
#(15) 160200  P   WALL/COL. ELECT. CONDUITS
 (18) 161100  N   ELECTRICAL RISERS
 (19) 161500  N   ELECTRICAL WIRING
#(20) 1655MN      ELECT. CONDUITS MAIN SLAB
#(22) 300100  P   SLAB REINFORCEMENT
#(23) 300200  P   WALL/COL. REINFORCEMENT
#(28) 3055MN      REINFORCE MAIN SLAB
#(29) 510100  P   FLOOR VENTILATION DUCTS
 (30) 510200  N   DRYER AND TOILET DUCTS
 (32) 511100  N   VENTILATION RISERS
#(33) 5155MN      FLOOR VENT. DUCTS MAIN FLOOR
 (34) 710100  N   RIGID INSULATION
#(35) 7221RF      METAL DECKING
#(36) 7222PU      STEEL FRAMING - PENTHOUSE
 (37) 7373RF      WATERPROOFING EXT. MAIN SLAB
 (38) 740100  N   CAULK WINDOWS
 (39) 750100  N   WINDOW FRAMING
 (40) 750200  N   WINDOW GLAZING
#(42) 610000  P   SLAB FORMWORK
#(43) 610100  N   WALL/COL. FORM
#(44) 610200  P   WALL/COL. STRIP FORM
#(45) 611100  P   PLACE/FINISH FLOOR SLAB
 (46) 615000  N   STUDDING EXTERIOR WALLS
 (47) 615100  N   EXTERIOR STUD SHEATHING
 (46) 616100  N   INTERIOR STUDDING
#(49) 617100  N   INTERIOR INSULATION & GYPSUM
#(50) 617200  S   GYPSUM JOINTS
#(60) 6206PK      COMPACTION/FILLING OF SUBBASE
#(65) 6250FA      FORM,POUR,STRIP SW WALLS
#(66) 6355PK      POUR SLAB FOR PARKING LEVEL
#(67) 6356MN      FORM MAIN SLAB
#(68) 6357MN      PLACE/FINISH MAIN SLAB
```

Figure 2-28   May 20, 1987 Linear Planning Schedule.

APARTMENT BUILDING 43RD & YEW

LINEAR PLANNING CHART

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+--------------------------------+
K : #  critical act.             :
E : p  act. has procurement seq. :
Y : c  completed                 :
+--------------------------------+
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Report Date     : 1987-05-20
Report Time     : 14:54:20
File Used       : C:\REPCONC\YEW
Revision Number : 1
Progress as of  :
Schedule Window
  From 01MAY87  To 30NOV87
  From LS To S2
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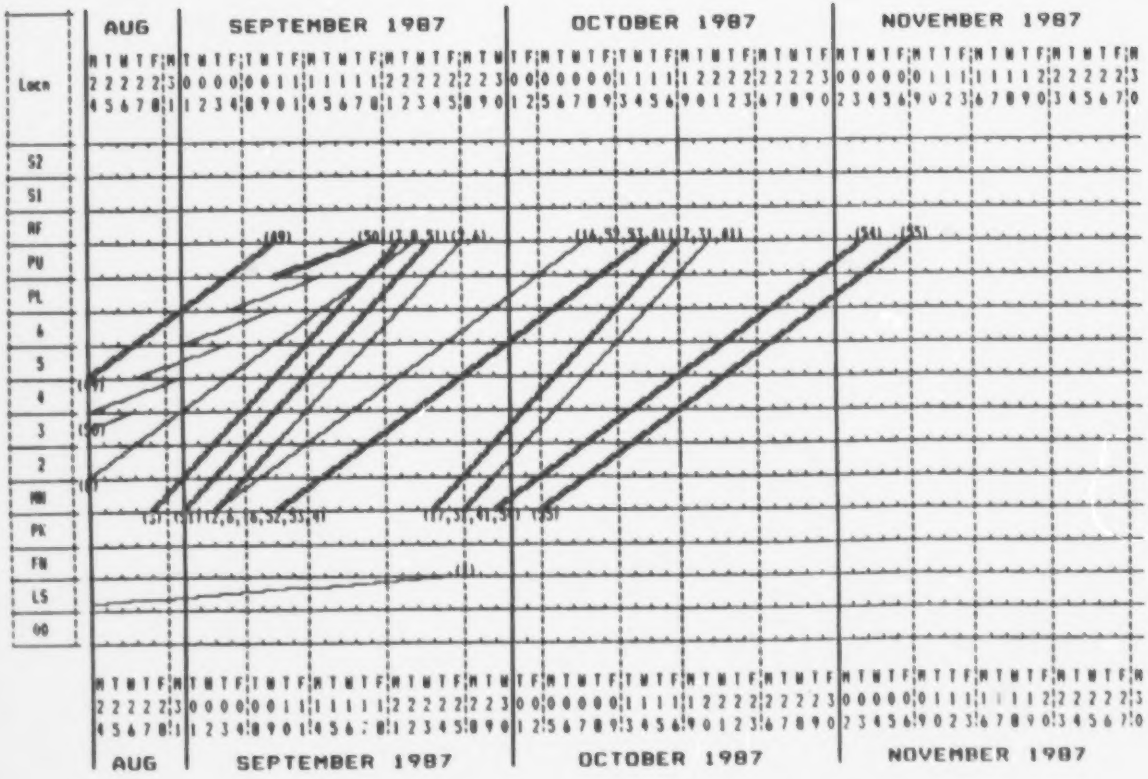


ACTIVITY KEY

	Act No	Type	Act Description
(1)	0121LS		LANDSCAPING
#(2)	060100	N	KITCHEN/BATHROOM CABINET
#(3)	100100	N	PAINT PRIMER COAT
#(4)	100200	N	PAINT FINISH COAT
#(6)	110100	N	CERAMIC TILES
(8)	150300	N	PLUMBING FINISHING
(16)	160300	N	ELECTRICAL FINISHING
#(17)	160500	N	ELECTRICAL FIXTURES
#(31)	510500	N	VENTILATION FINISHING
#(41)	920100	N	CARPETING
#(49)	617100	N	INTERIOR INSULATION & GYPSUM
#(50)	617200	S	GYPSUM JOINTS
#(51)	617300	N	PLASTER CEILING
(52)	618000	N	FINISH CARPENTRY
(53)	618100	N	HARDWARE FINISHING
#(54)	619000	N	CLEAN APARTMENTS
#(55)	619100	N	APARTMENT DEFICIENCIES

Figure 2-28 (cont'd)

The small size of the floor plate made it difficult to estimate durations for subtrade work. The general contractor had no take-off of subtrade work and had little basis for estimating how long an activity should take other than asking the subtrade itself. So subs would make their own assessment and simply not show up until they figured they had continuity of work.

At this time, BJ knew the date when he would be moving to the next project - when the current one was topped out.

Some refinement of the description of the rough-in work was done. The job was already experiencing difficulties in receiving accurate shop drawings.

The location sequence for rough-in and finishing work was still forecast to be MN - PU.

July 8, 1987 Site Visit

Mechanical foreman still ill.

Hydro and B.C. Tel not cooperative in providing completion dates for their work.

Forming crew now 6 men.

BJ asserts standardization of project logic not practical. Each superintendent approaches a project differently. He suggested that the students talk to the superintendent that had just been hired for a new project awarded to the firm. The project involved an 11 storey building with one suite per floor. For that job, the stairs would lag behind the slabs by two floors.

July 20, 1987 Site Meeting

The notes from this site meeting are shown in Figure 2-29. They show the nature of the discussion that took place at most site meetings and how discussions were documented.

July 24, 1987 Site Visit

Studding work has been interrupted because it ran into the reshores for the structure. At first the claim was that this was not important. As long as the sub was provided with sufficient lead time to reallocate resources to other projects, no complaints would be forthcoming and tradesmen would return when work was available. However, the drywall sub refused to come back until guaranteed continuity of work.

Mechanical room still not started. Sprinklers in parkade starting today.

July 31, 1987 Site Visit

RS preparing to take over from BJ. He is very responsive to the student's questions.

All reshoring has been removed. Steel studding has restarted.

Planters on street level being formed.

Shop drawings for steel roof have not been received.

Meeting @ Tiffany's Place with Bill
(on July 20th, 1987)

- *superstructure poured* as on schedule; balconies curbs poured during the week.
- *metal studding* has been interrupted by reshores on the 4th floor. Studding was started on Monday Jul 13th and will restart on Monday Jul 27th.
- In terms of *Importance of Work Continuity*, the subtrade can interrupt their work as long as they are given a couple of days of warning.
- *parkade sprinklers* in the parkade has not started as on schedule. Recall the Mech./Plumbing foreman is ill. Its is behind by a week.
- Logic for *exterior enclosure*:

  aluminum window frames --> scaffolding --> exterior sheathing & rigid insulation --> stucco

  the above should take one month all together. Sheathing is usually after scaffolding although the worker can hang out of the building to do it. (WCB won't allow it)
- *caulking of windows* is before painting. Bill said he'd rather have paint on the caulk than caulking on the paint.
- caulking of windows is suppose to be before interior insulations and drywall, but experience has had no moisture problems even if the logic was backwards. For example, for St. Moritz, the caulking was done after interior drywall.
- in terms of *sealing the building* before interior finishings, having exterior wall, vapour barrier and sheathing on the outside is sufficient.
- all shoring will be out by end of next week, studding can continue and others like liners and risers can also begin.
- *Plumbing risers* have began with holes punched in the floors but no pipes yet.
- *windows and door liners* will start this week and depend on the removal of reshores for continuity. the duration of 1 day/floor is OK.
- *cleaning apartments* can be done in 2 days/floor but the deficiencies may take on and off for over a month.
- *gas fireplaces* will take 1 day to install for all floors. The installation depends on the completion of :
  - steel framing on chimney
  - drywalling of fire-rated chimney shaft
  - scaffolding
- *block work for the elevator* will take 3 days for the whole building and will start after the elevator frames are in.
- *permanent power* will start in one month but Hydro is unpredictable. The power pole near the driveway has been relocated but they have to install a couple of control boxes underground before power can be led into the building.
- *lobby features* details are still minimal but drop ceilings have been mentioned and be incorporated into the drywalling activities. Any other activities will be done on a fill-in basis.
- *railings for the balcony* will begin 1 week after stucco of exterior.
- *tower crane* will be removed in about 3 weeks after the roof in and drywalls loaded into the building. No word on how subsequent material will be loaded up although they usually use a mobile crane.
- the *roof of the building* will have two end sloping walls on the east and west face of the building. Steel framing will take place after these end walls are poured. The only details Bill has are what we have and some shop drawings that are wrong anyway. The *shop drawings* have been wrong for two weeks and still no word on arrival of corrected ones.

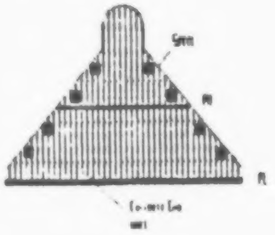


Figure 2-29 Notes from July 20, 1987 Site Meeting.

August 6, 1987 Site Visit

RS now in charge.

Scaffolding is to start after completion of planters.

Structural steel subtrade is undermanning the job.

August 14, 1987 Site Visit

RS is relying on the schedule produced to date as it is the only one that exists. Up until his arrival, it had been difficult to obtain accurate update information from BJ.

Progress as of this date is summarized in figure 2-30. The client has now asked for project completion as of October 1, 1987. A date of November 1, 1987 is promised by JM, apparently with no reference to the current schedule.

The schedule was updated as a follow up to this meeting. Project completion is now forecast to be December 3, 1987.

August 26, 1987 Schedule - Progress as of August 21, 1987

A site visit was made on August 21 for further updating. Notes were recorded directly on the August 14 updated schedule. Discussions with RS led to a refinement of some duration estimates - e.g. plaster ceiling, kitchen and bathroom cabinets (later would find it better to break these up) and ventilation finishing. The multiple pass nature of finish carpentry is briefly discussed but not yet incorporated into the schedule.

The schedule resulting from this updating is shown in figure 2-31. Project completion is now forecast to be January 6, 1988. Finally, the project manager, JM, gets involved regarding schedule matters. He doesn't believe the date but is concerned, given his commitment to a November 1 completion date.

The location sequence for finishing work is still MN - PU.

August 31, 1987 Schedule - Progress as of August 26, 1987

A site visit took place August 27 to record progress. A meeting was also held with JM at the office. See notes in figure 2-31 re both meetings.

A meeting is held with RS on August 28. Notes are recorded directly on the current schedule - see figure 2-32. The goal is now to see if a November 1 completion is feasible.

August 31, 1987 Schedule - Progress as of August 26, 1987

Based on the August 27 and 28 visits and discussions, the schedule is updated and revised. The new completion date is forecast to be December 9, 1987 - see figure 2-33. Individual activity durations are changed significantly - for example, drywall moves from 2 days/floor to 4 days/floor. A double crew strategy is adopted.

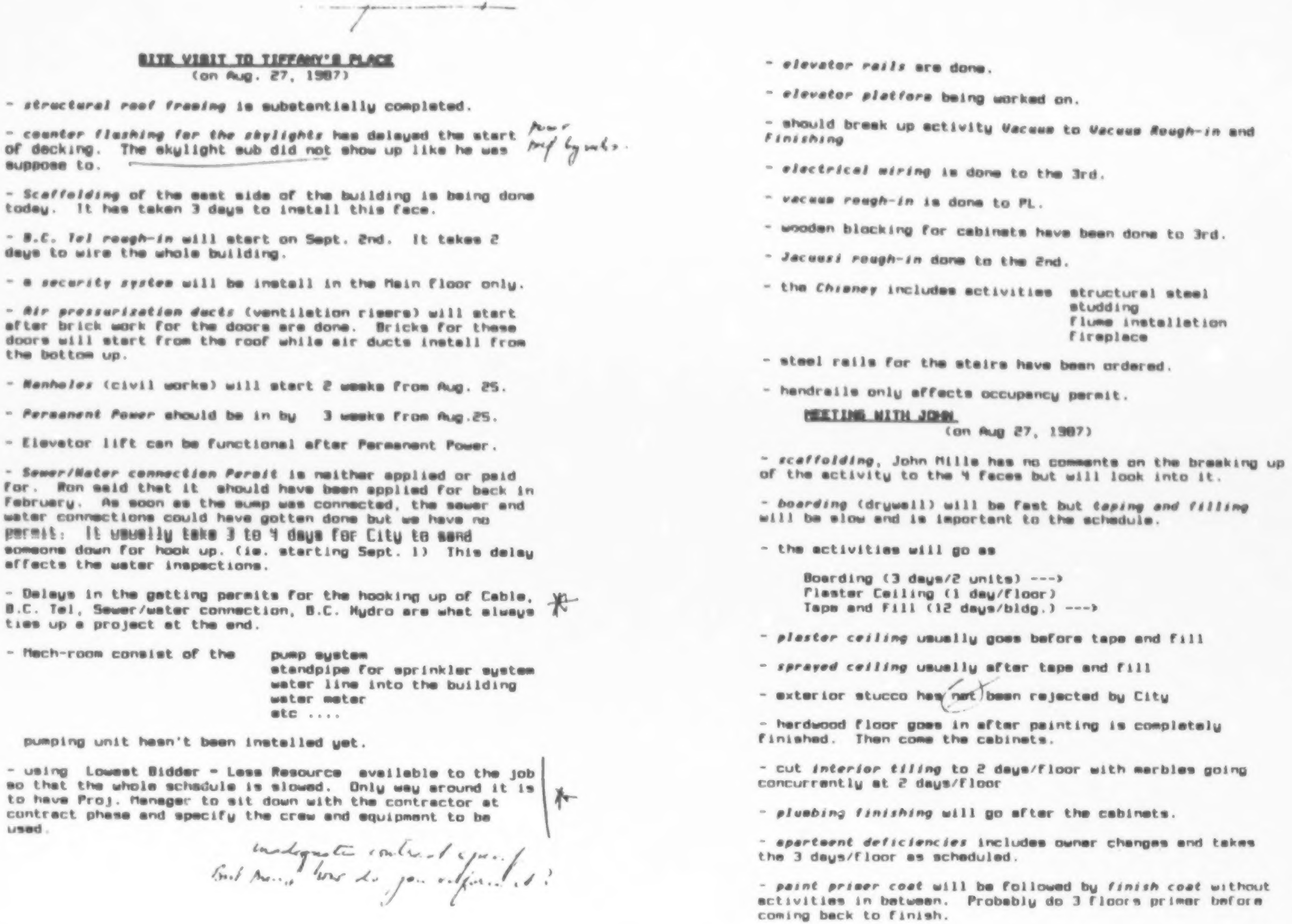
RS is now using the field update report for recording progress - figure 2-34. For revision to this report, note that RS thinks in terms of completion dates, not days to completion. RS begins adding activities to track bathtub framing, wood backing, upper penthouse stairs.

SITE VISIT @ TIFFANY'S PLACE

(August 14, 1987)

- *Exterior Sheathing* done upto 6th.
- *Balcony Doors* installed to PU.
- *Windows* completed to the 2nd and 50% done for the 3rd.
- *Planter Walls* all poured.
- *Roof Framing* 90% completed. *Decking* have arrived on site and ready to be installed.
- *Studding* completed to PU
- Electrical risers completed to PU, including Electrical Panel boxes.
- *Window Liners* installed to PU
- *Wastewater Risers* completed to PU.
- Masonry for elevator shaft loaded to each floor.
- Fire Extinguisher Boxes installed to PU.
- Ron has been using the *Repcon Bar Chart* as a "guide". he has some markings on the chart on 2 activities that have been completed on time and one that haven't.
  - i) Studding finished on Aug 6th.
  - ii) Window Liners finished by Aug 14th
  - iii) Steel Framing 10 days late.
- *Tower Crane* will be dissembled on Tuesday.
- *Scaffolding* will be done next week. The crane would help in the assembly but they can pulley the parts up if the crane is gone. The scaffolding is apparently contracted by the subs. and not so Ron doesn't promise them the crane. John has given them notice that the crane will be downed Tuesday though so that they can make use of it if they want.
- the owner has suddenly asked for a *project completion* of October 1st. John has now promised Nov. 1st. The client had not brought up this issue before.

Figure 2-30 Notes from August 14, 1987 Site Visit.



SITE VISIT TO TIFFANY'S PLACE

(on Aug. 27, 1987)

- *structural roof framing* is substantially completed.

- *counter flashing for the skylights* has delayed the start of decking. The skylight sub did not show up like he was suppose to.

poor perf by subs.

- *Scaffolding* of the east side of the building is being done today. It has taken 3 days to install this face.

- *B.C. Tel rough-in* will start on Sept. 2nd. It takes 2 days to wire the whole building.

- a *security system* will be install in the Main floor only.

- *Air pressurization ducts* (ventilation risers) will start after brick work for the doors are done. Bricks for these doors will start from the roof while air ducts install from the bottom up.

- *Manholes* (civil works) will start 2 weeks from Aug. 25.

- *Permanent Power* should be in by 3 weeks from Aug.25.

- Elevator lift can be functional after Permanent Power.

- *Sewer/Water connection Permit* is neither applied or paid for. Ron said that it should have been applied for back in February. As soon as the sump was connected, the sewer and water connections could have gotten done but we have no permit. It usually take 3 to 4 days for City to send someone down for hook up. (ie. starting Sept. 1) This delay affects the water inspections.

- Delays in the getting permits for the hooking up of Cable, B.C. Tel, Sewer/water connection, B.C. Hydro are what always ties up a project at the end. *

- Mech-room consist of the
  - pump system
  - standpipe for sprinkler system
  - water line into the building
  - water meter
  - etc ....

pumping unit hasn't been installed yet.

- using Lowest Bidder - Less Resource available to the job so that the whole schedule is slowed. Only way around it is to have Proj. Manager to sit down with the contractor at contract phase and specify the crew and equipment to be used. *

inadequate contract spec./
But how do you enforce it?

- *elevator rails* are done.

- *elevator platform* being worked on.

- should break up activity *Vacuum* to *Vacuum Rough-in* and *Finishing*

- *electrical wiring* is done to the 3rd.

- *vacuum rough-in* is done to PL.

- wooden blocking for cabinets have been done to 3rd.

- *Jacuusi rough-in* done to the 2nd.

- the *Chimney* includes activities
  - structural steel
  - studding
  - flume installation
  - fireplace

- steel rails for the stairs have been ordered.

- handrails only affects occupancy permit.

MEETING WITH JOHN

(on Aug 27, 1987)

- *scaffolding*, John Mills has no comments on the breaking up of the activity to the 4 faces but will look into it.

- *boarding* (drywall) will be fast but *taping and filling* will be slow and is important to the schedule.

- the activities will go as

  Boarding (3 days/2 units) --->
  Plaster Ceiling (1 day/floor)
  Tape and Fill (12 days/bldg.) --->

- *plaster ceiling* usually goes before tape and fill

- *sprayed ceiling* usually after tape and fill

- exterior stucco has not been rejected by City

- hardwood floor goes in after painting is completely finished. Then come the cabinets.

- cut *interior tiling* to 2 days/floor with marbles going concurrently at 2 days/floor

- *plumbing finishing* will go after the cabinets.

- *apartment deficiencies* includes owner changes and takes the 3 days/floor as scheduled.

- *paint primer coat* will be followed by *finish coat* without activities in between. Probably do 3 floors primer before coming back to finish.

Figure 2-31 Notes from August 27, 1987 Site and Office Meetings.

Summaries
notes of 28 Aug 87
meeting at site
with Ron

```
                                TIFFANY PLACE   (43RD & YEW)                                        Page 1 of 5

                                          BAR CHART
                                                                                              Report Date     : 1987-08-26
             +--------------------------------------------------------------+                 Report Time     : 16:01:39
           K :  S  start date            #  critical activity          -  float  :            File Used       : C:\REPCON\PROJ1\TI
           E :  F  finish date           x  non-critical activity               :            Revision Number : 1
           Y :  p  start procurement     #  activity with negative float        :            Progress as of  : 1987-08-21
             :                           c  completed                           :            Schedule Window
             +--------------------------------------------------------------+                   From 02JUL87  To 27JAN88
                                                                                                From LS To S2
```

Field Report for Langara — how different is it to include placement?

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                              :8787  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87 87 88 88  88  88  88  88  88  88  88  88  88  88  88  88  88
NO.    TYPE  DESCRIPTION      :JUJUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC DEC DECDECJAN JAN JAN JAN FEB FEB FEB FEB FEB MAR MAR MAR MAR APR
                              :2 6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7   14  21 28 4  11  18  25  1   8   15  22  29  7   14  21  28  4
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                              :. PL  PU  .   .   .   .   .   :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
0610100 R WALL/COL. FORM      :. S-  S-  .   .   .   .   .   :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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0160200 P WALL/COL. ELECT.    :. S-  S-  .   .   .   .   .   :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          CONDUITS            :..............................:............................................................................................................................
                              :. PL  PU  .   .   .   .   .   :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
0300200 P WALL/COL.           :. S-  S-  .   .   .   .   .   :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          REINFORCEMENT       :..............................:............................................................................................................................
                              :6 .PL  .PU .   .   .   .   .  :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
0610000 P SLAB FORMWORK       :F-.SCF-.SCF-.  .   .   .   .  :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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0610200 P WALL/COL. STRIP FORM:. .S-  .S- .   .   .   .   .  :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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0150100 P PLUMBING SLEEVING   :F-. SF-. SF-.  .   .   .   .  :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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0160100 P ELECTRICAL CONDUITS :F-. SF-. SF-.  .   .   .   .  :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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0300100 P SLAB REINFORCEMENT  :F-. SF-. SF-.  .   .   .   .  :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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0510100 P FLOOR VENTILATION   :F-. SF-. SF-.  .   .   .   .  :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          DUCTS               :..............................:............................................................................................................................
                              :.6.  PL  PU  .   .   .   .    :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
0611100 R PLACE/FINISH FLOOR  :-S----S-  S-  .   .   .   .   :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          SLAB                :..............................:............................................................................................................................
                              :PK.   .   .   .   .   .   .   :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 1560PK   SPRINKLERS IN       :CCCCCCCCCCCCCCCCCCCCF---------  .   :.  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
          PARKADE             :..............................:............................................................................................................................
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                              :8787  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87 87 88 88  88  88  88  88  88  88  88  88  88  88  88  88  88
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                              :2 6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7   14  21 28 4  11  18  25  1   8   15  22  29  7   14  21  28  4
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Figure 2-32   August 21, 1987 Schedule Update.

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                               :. .   M23 .   .  45 6PL   PU :.
0615000 W STUDDING EXT./INT.   :. .   SSSF---- 00000SSFSSF0000SCCCF.
          WALLS
                               :......................................:.........................................................
                               :. .   .   PK  .   .   .   .  :.
1630PK   ELECTRICAL ROOM       :. .   .   SCCCF---------------------------------------------
                               :......................................:.........................................................
                               :. .   .  .M234.   56PPU   .  :.
750300 P WINDOW/DOOR LINERS    :. .   . 0000SSSS--  0SSSS-----.  :.
                               :......................................:.........................................................
                               :. .   .   . MM2 3 .   .   456PL.
151100 P WATER SUPPLY RISERS   :. .   .  .00SFS SF .  .   SSSS---------
                               :......................................:.........................................................
                               :. .   .   . MM2 3  4 5 6 PL . :.
151200 P WASTE-WATER RISERS    :. .   .  000SFSFSF0SFSFSFSF--  :.
                               :......................................:.........................................................
                               :. .   .   . MM2 3 4.   .56PL.  :PU
161600 P ELECTRICAL RISERS     :. .   .  .00SFSFSFSCCCCFSSSF--  :S---------------
                               :......................................:.........................................................
                               :. .   .   . MM2  .   .   3456PLPU
161500 W ELECTRICAL            :. .   .   . SFSF-- .  .   SSSSSFSIF---------------
          WIRING/ROUGH-IN
                               :......................................:.........................................................
                               :. .   .   .   .   M23456   .  :PL PU.
0615100 W EXTERIOR STUD        :. .   . 00000000000SSSSSSF000000SIFSIF
          SHEATHING
                               :......................................:.........................................................
                               :. .   .   .   .   .PU .   .  :.
07222PU  STEEL FRAMING -       :. .  .0000000000000000SCCCCCCCCCCCCCF
          PENTHOUSE
                               :......................................:.........................................................
                               :. .   .   .   .   .  36PL .  :.
151700 P FIRE CABINETS &       :. .   .   .   .   0000SSSCCCCIIIF---------
          HOSES -
                               :......................................:.........................................................
                               :. .   .   .   .   .  246PPU  :.
750100 W ALUMINUM WINDOWS &    :. .   .  00000000000000SSSSSCCCIIF
          DOORS
                               :......................................:.........................................................
                               :. .   .   .   .   .   .   2456PLPU
151500 W PLUMBING ROUGH-IN     :. .   .   .   .   .   .   SSSSSFSIF---------------
                               :......................................:.........................................................
                               :. .   .   .   .   .   .   2456PL   . PU.
310200 W DRYER AND TOILET      :. .   .   .   .   .   .   SSSSSF-------SF-----------
          DUCTS
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                               :. .   .   .   .   .   .   .  :00
1022100  SCAFFOLD ALL FLOORS   :. .   .   .   .   .   .   .  :S000F.
                               :......................................:.........................................................
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042100   HYDRO MANHOLES        :. .   .   .   .   .   .   .  :SF-------------------------------------------
                               :......................................:.........................................................
                               :. .   .   .   .   .   .   .  :00
052100   TELEPHONE MANHOLES    :. .   .   .   .   .   .   .  :SF-------------------------------------------
                               :......................................:.........................................................
                               :. .   .   .   .   .   .   .  :M23456PPU .
511100 P VENTILATION RISERS    :. .   .   .   .   .   .   .  :SSSSSSSS----------.
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                               :8787 87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  8787 88 88  88  88  88  88  88  88  88  88  88  88  88  88
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                               :2 6  13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7   14  21 28 4  11  18  25  1   8   15  22  29  7   14  21  28  4
```

Fin

at 3rd floor

Front sheathing comp with scaffolding

95% (finished so roof can proceed)

cabinets in

finished at East

100% complete

100% complete + inspected : Does not include setting tubs – must be in before drywall

(6th floor tubs is special order will be delay 6th fl. bath finish

Everything but PH.

out

change due to 15 days

} Marked out Aug 25 will be done in [illegible] time than few days after pull'n power cable. Permanent power by Sept 15 – interfaces with elevator – need power for elevator within one week

2 days total. post chart day after [illegible] day

Figure 2-32 (cont'd)

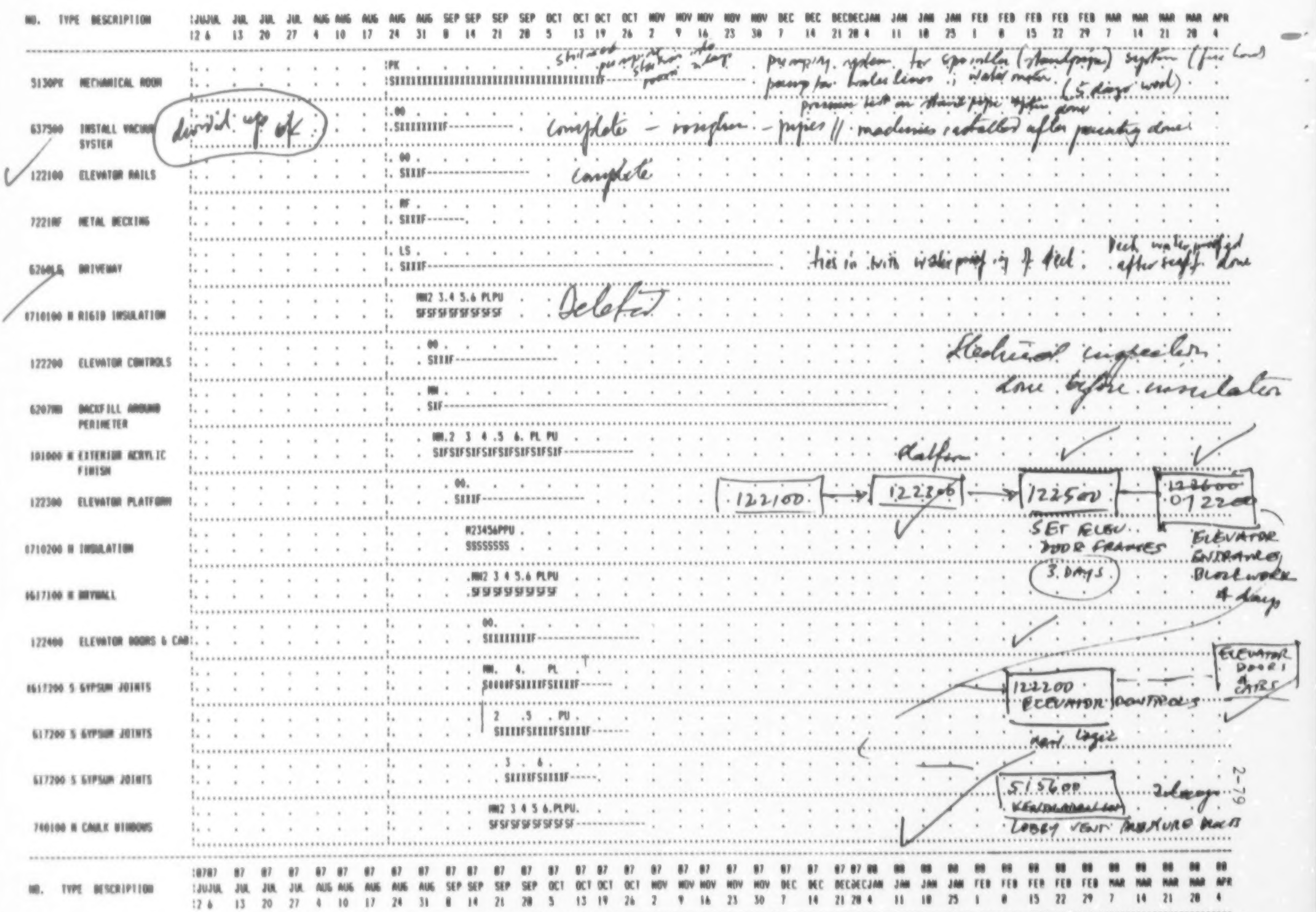
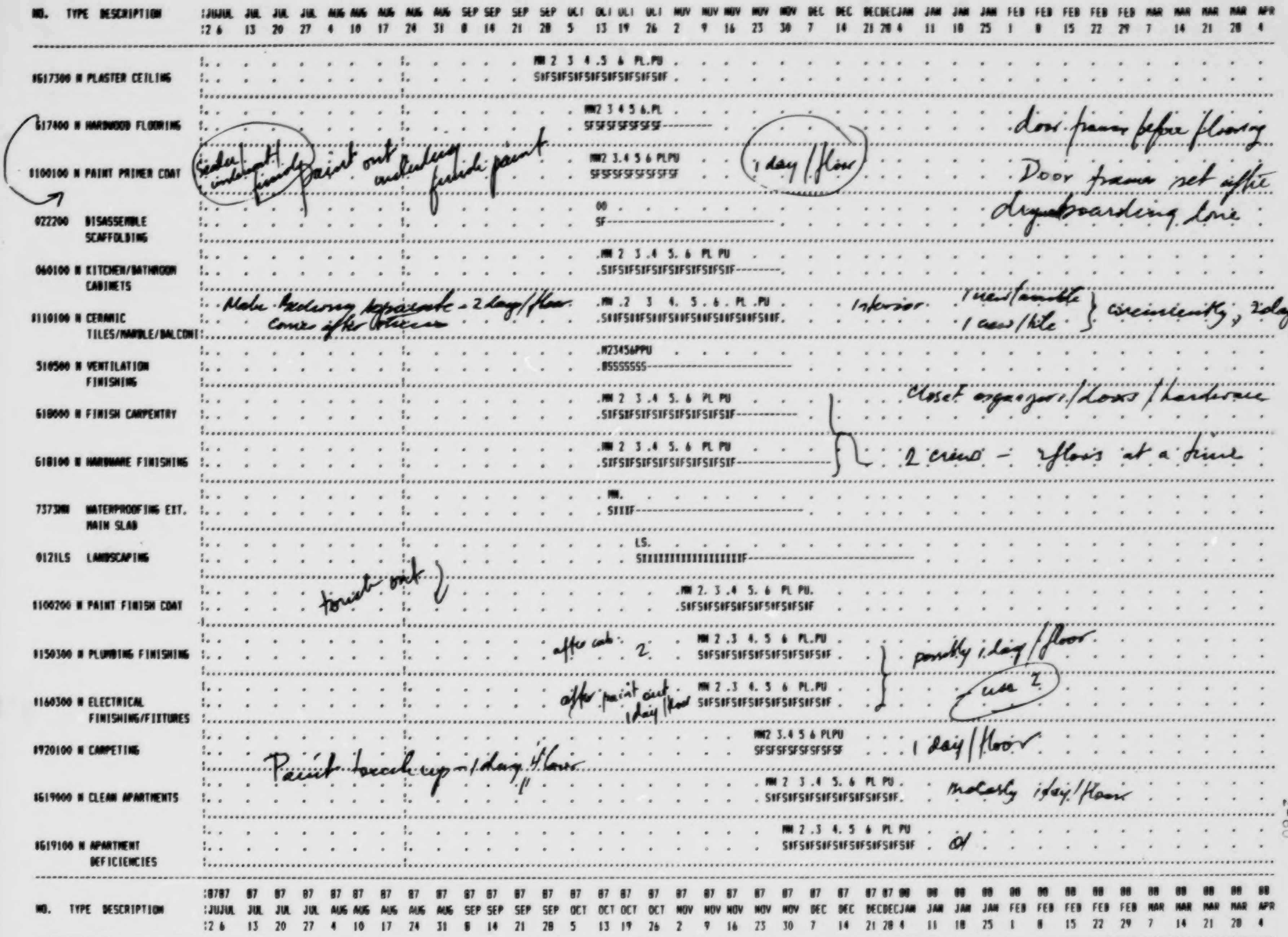


Figure 2-32 (cont'd)



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NO.      TYPE DESCRIPTION       :JUJUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC DEC DECDECJAN JAN JAN JAN FEB FEB FEB FEB FEB MAR MAR MAR MAR APR
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                                                                                  MM 2  3  4 .5  6  PL.PU
#617300  N PLASTER CEILING                                                        SIFSIFSIFSIFSIFSIFSIFSIF

                                                                                         MM2 3 4 5 6.PL
617400   N HARDWOOD FLOORING                                                             SFSFSFSFSFSFSF--------

                                                                                         MM2 3.4 5 6 PLPU
#100100  N PAINT PRIMER COAT                                                             SFSFSFSFSFSFSFSF

                                                                                          00
022200     DISASSEMBLE                                                                    SF---------------------------
           SCAFFOLDING

                                                                                         .MM 2  3 .4  5. 6  PL PU
060100   N KITCHEN/BATHROOM                                                              .SIFSIFSIFSIFSIFSIFSIFSIF--------.
           CABINETS

                                                                                         .MM .2  3  4.  5 . 6 . PL .PU
#110100  N CERAMIC                                                                       .SIIFSIIFSIIFSIIFSIIFSIIFSIIFSIIF.
           TILES/MARBLE/BALCONI

                                                                                         .MZ3456PPU
510500   N VENTILATION                                                                   .BSSSSSSS----------------------
           FINISHING

                                                                                         .MM 2  3 .4  5. 6  PL PU
618000   N FINISH CARPENTRY                                                              .SIFSIFSIFSIFSIFSIFSIFSIF----------

                                                                                         .MM 2  3 .4  5. 6  PL PU
618100   N HARDWARE FINISHING                                                            .SIFSIFSIFSIFSIFSIFSIFSIF---------------

                                                                                          . MM.
7373MM     WATERPROOFING EXT.                                                             . SIIIF----------------------------
           MAIN SLAB

                                                                                               LS.
0121LS     LANDSCAPING                                                                          SIIIIIIIIIIIIIIIIIIF--------------------------

                                                                                                      .MM 2. 3 .4  5. 6  PL PU.
#100200  N PAINT FINISH COAT                                                                          .SIFSIFSIFSIFSIFSIFSIFSIF

                                                                                                          MM 2 .3  4. 5  6  PL.PU
#150300  N PLUMBING FINISHING                                                                             SIFSIFSIFSIFSIFSIFSIFSIF

                                                                                                          MM 2 .3  4. 5  6  PL.PU
#160300  N ELECTRICAL                                                                                     SIFSIFSIFSIFSIFSIFSIFSIF
           FINISHING/FIXTURES

                                                                                                                  MM2 3.4 5 6 PLPU
#920100  N CARPETING                                                                                              SFSFSFSFSFSFSFSF

                                                                                                                  .MM 2  3 .4  5. 6  PL PU.
#619000  N CLEAN APARTMENTS                                                                                        SIFSIFSIFSIFSIFSIFSIFSIF.

                                                                                                                     MM 2 .3  4. 5  6  PL PU
#619100  N APARTMENT                                                                                                 SIFSIFSIFSIFSIFSIFSIFSIF
           DEFICIENCIES
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                                :8787  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87  87 87 88 88  88  88  88  88  88  88  88  88  88  88  88  88
NO.      TYPE DESCRIPTION       :JUJUL JUL JUL JUL AUG AUG AUG AUG AUG SEP SEP SEP SEP OCT OCT OCT OCT NOV NOV NOV NOV NOV DEC DEC DECDECJAN JAN JAN JAN FEB FEB FEB FEB FEB MAR MAR MAR MAR APR
                                :2 6   13  20  27  4   10  17  24  31  8   14  21  28  5   13  19  26  2   9   16  23  30  7   14  21 28 4  11  18  25  1   8   15  22  29  7   14  21  28  4
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Sealer / undercoat / finish

Paint out / underlay / finish paint

1 day / floor

door frames before flooring

Door frame set after drywallboarding line

Make balcony separate – 2 days/floor
Come after [illegible]

Interior

Tiles/marble
1 crew/tile } concurrently, 2 days/floor

Closet organizers/doors/hardware

2 crews – 2 floors at a time

touch out }

after cab. 2

after paint out
1 day/floor

possibly 1 day/floor

use 2

1 day/floor

Paint touch up – 1 day/floor

mostly 1 day/floor

ok

Figure 2-32 (cont'd)

```
NO.   TYPE  DESCRIPTION      :JUJUL  JUL  JUL  JUL  AUG AUG  AUG  AUG  AUG  SEP SEP  SEP  SEP  OCT  OCT OCT  OCT  NOV  NOV NOV  NOV  NOV  DEC  DEC  DECDECJAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB  FEB  MAR  MAR  MAR  MAR  APR
                             :2 6    13   20   27   4   10   17   24   31   8   14   21   28   5    13  19   26   2    9   16   23   30   7    14   21 28 4    11   18   25   1    8    15   22   29   7    14   21   28   4
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                             :. .    .    .    .    .   .    .    :.   .    .   .    .    .    .    .   .    .    .    .   .    .    .    .    .    . . . 00.  .    .    .    .    .    .    .    .    .    .    .    .    .
1636000  FINISH              :. .    .    .    .    .   .    .    :.   .    .   .    .    .    .    .   .    .    .    .   .    .    .    .    .    . . . 5 .  .    .    .    .    .    .    .    .    .    .    .    .    .
                             :.......................................:.............................................................................................................................................
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                             :0787   87   87   87   87  87   87   87   87   87  87   87   87   87   87  87   87   87   87  87   87   87   87   87   87 87 88  88   88   88   88   88   88   88   88   88   88   88   88   88
NO.   TYPE  DESCRIPTION      :JUJUL  JUL  JUL  JUL  AUG AUG  AUG  AUG  AUG  SEP SEP  SEP  SEP  OCT  OCT OCT  OCT  NOV  NOV NOV  NOV  NOV  DEC  DEC  DECDECJAN  JAN  JAN  JAN  FEB  FEB  FEB  FEB  FEB  MAR  MAR  MAR  MAR  APR
                             :2 6    13   20   27   4   10   17   24   31   8   14   21   28   5    13  19   26   2    9   16   23   30   7    14   21 28 4    11   18   25   1    8    15   22   29   7    14   21   28   4
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
```

Backfill to start Aug 28
should be finished Monday or
Tuesday

Once have perm. power can remove temp power,
then can complete balance of retaining wall
+ garbage encl. in lane

1 day insulation
boarding
2 crews -
3 days/floor
plaster - 1 day/floor
Tape cleanup + bead

G37600

hydraulic line installed
piping in conduit Thurs/Friday

building cab platform on site - now
when installed, go up to top of
'Bldg + work down installing
door frames

brick
when door frame down,
brick can start
Monday or Tuesday
Aug 31, Sept 1

owner delay
in paying
for application
permit

no conformation. contract not yet assigned

Cable Vision + BC Tel

~~Cab~~ Permit Appl. resolved just this week.

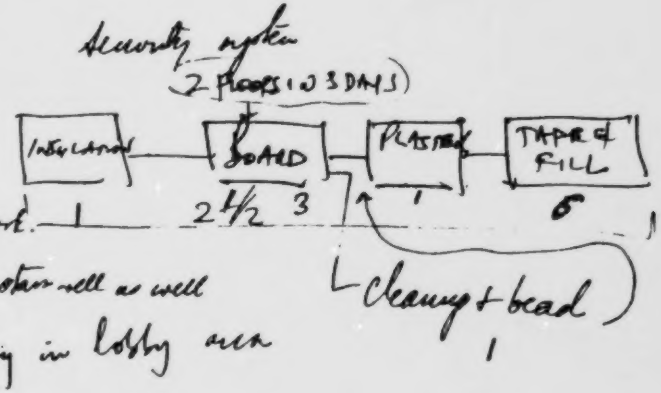
BC. Tel roughin - 2 working
days

Sept 2 start

Security system

when brick work finished on door frame,
air pressurization risers can go in

2 1/2 - 3 floors/day for brick work.



Bricking in standpipe in stairwell as well

Then could proceed with wall framing + drop ceiling in lobby area
1/2 day / floor

no keys or the bel or cable wire

Figure 2-32 (cont'd)

REPCON™

TIFFANY PLACE (43RD & YEW)

LINEAR PLANNING CHART

```
+------------------------------------+
K : #  critical act.                 :
E : p  act. has procurement seq.     :
Y : c  completed                     :
+------------------------------------+
```

Report Date : 1987-08-31
Report Time : 12:08:36
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
Progress as of : 1987-08-26
Schedule Window
From 24AUG87 To 11DEC87
From LS To RF

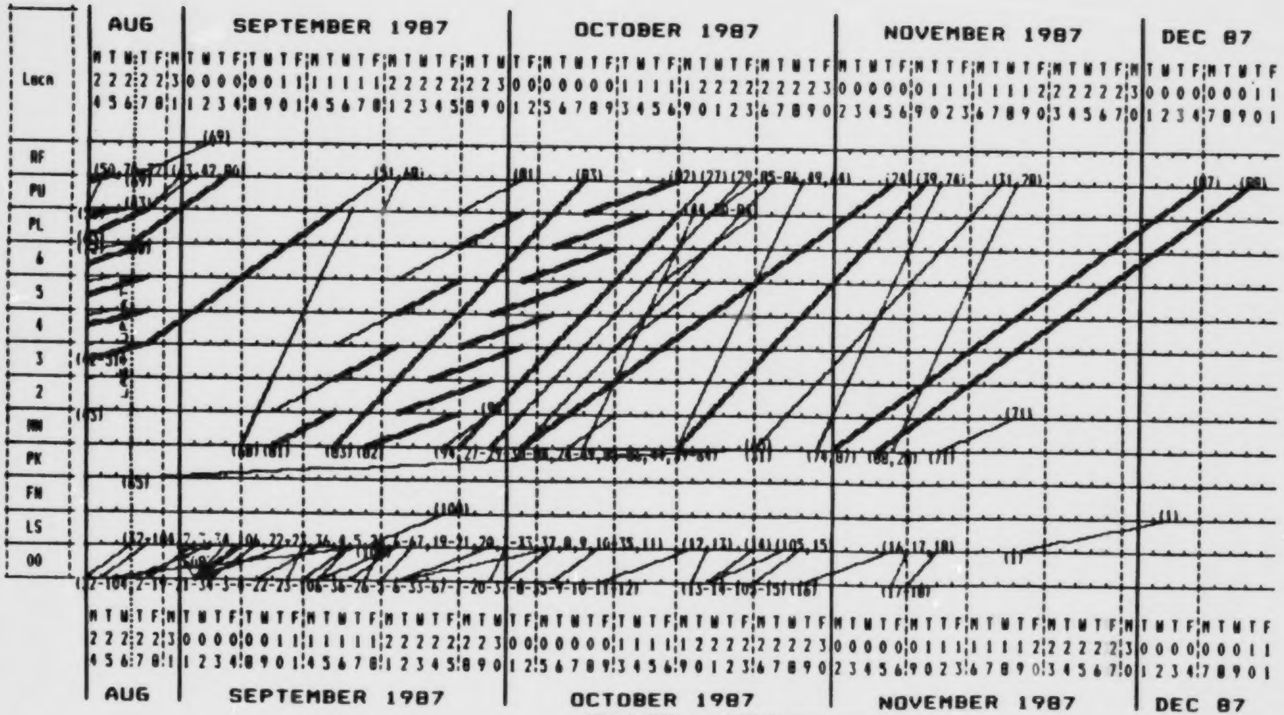


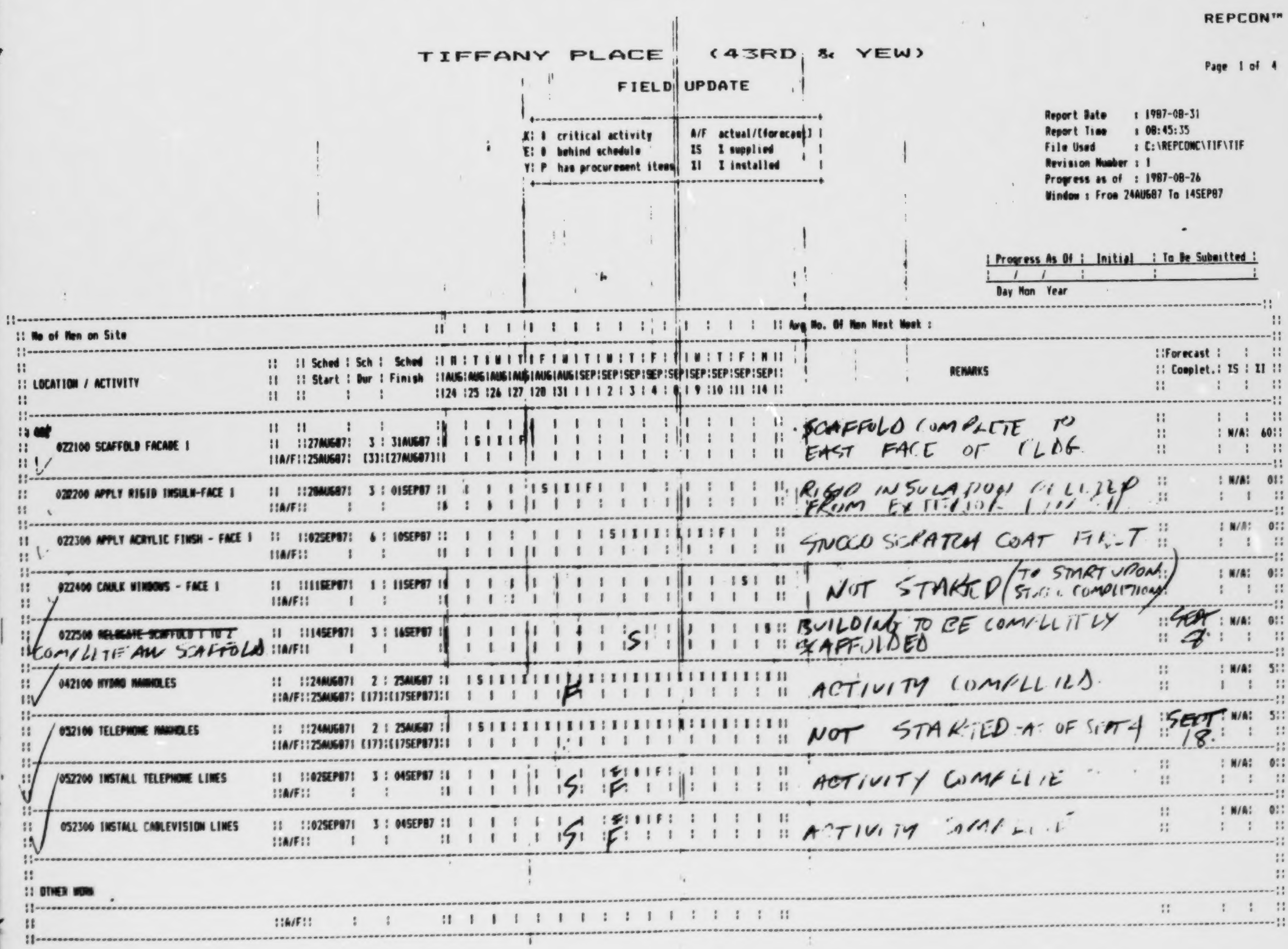
Figure 2-33 August 26, 1987 Schedule Update.

ACTIVITY KEY

	Act No	Type	Act Description
(1)	0121LS		LANDSCAPING
(2)	022100		SCAFFOLD FACADE 1
(3)	022200		APPLY RIGID INSULN-FACE 1
(4)	022300		APPLY ACRYLIC FINSH - FACE 1
(5)	022400		CAULK WINDOWS - FACE 1
(6)	022500		RELOCATE SCAFFOLD 1 TO 2
(7)	022600		APPLY RIGID INSULN - FACE 2
(8)	022700		APPLY ACRYLIC FINSH - FACE 2
(9)	022800		CAULK WINDOWS - FACE 2
(10)	022900		RELOCATE SCAFFOLDING 2 - 3
(11)	023000		APPLY RIGID INSULN - FACE 3
(12)	023100		APPLY ACRYLIC FINSH - FACE 3
(13)	023200		CAULK WINDOWS - FACE 3
(14)	023300		RELOCATE SCAFFOLDING 3 - 4
(15)	023400		APPLY RIGID INSULN - FACE 4
(16)	023500		APPLY ACRYLIC FINSH - FACE 4
(17)	023600		CAULK WINDOWS - FACE 4
(18)	023700		REMOVE SCAFFOLDING - FACE 4
(19)	042100		HYDRO MANHOLES
(20)	042200		CONNECT PERMANENT POWER
(21)	052100		TELEPHONE MANHOLES
#(22)	052200		INSTALL TELEPHONE LINES
#(23)	052300		INSTALL CABLEVISION LINES
#(24)	060100	N	KITCHEN/BATHROOM CABINETS
(26)	072200		ELEVATOR DOOR MASONRY
#(27)	100100	N	PAINT UNDER/PRIMER/FINSH COATS
(28)	100200	N	PAINT TOUCH-UP
(29)	110100	N	INSTALL CERAMIC TILES
(30)	110200	N	INSTALL MARBLE ENTRANCES
(31)	110300	N	INSTALL TILE BALCONIES
c(32)	122100		ELEVATOR RAILS
(33)	122200		ELEVATOR CONTROLS
(34)	122300		ELEVATOR PLATFORM
(35)	122400		ELEVATOR DOORS & CAB
(36)	122500		SET ELEVATOR DOOR FRAMES
(37)	122600		TEST ELEVATOR SYSTEM
#(39)	150300	N	PLUMBING FINISHING
#(42)	151500	N	PLUMBING ROUGH-IN
c(43)	151700	P	FIRE CABINETS/STANDPIPES
(44)	151800	N	FIRE CABINET HOSES/COVERS
(49)	160300	N	ELECTRICAL FINISHING/FIXTURES

#(80)	615100	N	EXTERIOR STUD SHEATHING
#(81)	617100	N	DRYWALL
#(82)	617200	S	GYPSUM JOINTS
#(83)	617300	N	PLASTER CEILING
#(84)	617400	N	HARDWOOD FLOORING
(85)	618000	N	FINISH CARPENTRY
(86)	618100	N	HARDWARE FINISHING
#(87)	619000	N	CLEAN APARTMENTS
#(88)	619100	N	APARTMENT DEFICIENCIES
(94)	6207MN		BACKFILL AROUND PERIMETER
(100)	6260LS		DRIVEWAY
c(104)	637500		VACUUM SYSTEM ROUGH-IN

c(50)	161100	P	ELECTRICAL RISERS
#(51)	161500	N	ELECTRICAL WIRING/ROUGH-IN
(63)	510200	N	DRYER AND TOILET DUCTS
(64)	510500	N	VENTILATION FINISHING
(65)	5130PK		MECHANICAL ROOM
(67)	515600		LOBBY VENT PRESSURE DUCTS
#(68)	710200	P	INSULATION
(69)	7221RF		METAL DECKING
#c(70)	7222PU		STEEL FRAMING - PENTHOUSE
(71)	7373MN		WATERPROOFING EXT. MAIN SLAB
c(72)	750100	N	ALUMINUM WINDOWS & DOORS
#(74)	920100	N	CARPETING



REPCON™

TIFFANY PLACE (43RD & YEW)

FIELD UPDATE

Page 1 of 4

X: ! critical activity
E: # behind schedule
Y: P has procurement items

A/F actual/(forecast)
IS % supplied
II % installed

Report Date : 1987-08-31
Report Time : 08:45:35
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
Progress as of : 1987-08-26
Window : From 24AUG87 To 14SEP87

Progress As Of	Initial	To Be Submitted
/ / Day Mon Year		

No of Men on Site

Avg No. Of Men Next Week :

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	M AUG 24	T AUG 25	W AUG 26	T AUG 27	F AUG 28	M AUG 31	T SEP 1	W SEP 2	T SEP 3	F SEP 4	T SEP 8	W SEP 9	T SEP 10	F SEP 11	M SEP 14	REMARKS	Forecast Complet.	IS	II
022100 SCAFFOLD FACADE 1		27AUG87	3	31AUG87		S	I	F												SCAFFOLD COMPLETE TO EAST FACE OF BLDG.		N/A	60
	A/F	25AUG87	[3]	[27AUG87]																			
022200 APPLY RIGID INSULN-FACE 1		28AUG87	3	01SEP87					S	I	F									RIGID INSULATION [illegible] FROM EXTERIOR [illegible]		N/A	0
	A/F																						
022300 APPLY ACRYLIC FINSH - FACE 1		02SEP87	6	10SEP87								S	I	I	I	I	F			STUCCO SCRATCH COAT FIRST		N/A	0
	A/F																						
022400 CAULK WINDOWS - FACE 1		11SEP87	1	11SEP87														S		NOT STARTED (TO START UPON STUCCO COMPLETION)		N/A	0
	A/F																						
022500 ~~RELOCATE SCAFFOLD 1 TO 2~~ COMPLETE ALL SCAFFOLD		14SEP87	3	16SEP87															S	BUILDING TO BE COMPLETELY SCAFFOLDED	SEPT 8	N/A	0
	A/F												S										
042100 HYDRO MANHOLES		24AUG87	2	25AUG87		S	I	I	I	I	I	I	I	I	I	I	I	I	I	ACTIVITY COMPLETED.		N/A	5
	A/F	25AUG87	[17]	[17SEP87]						F													
052100 TELEPHONE MANHOLES		24AUG87	2	25AUG87		S	I	I	I	I	I	I	I	I	I	I	I	I	I	NOT STARTED - AS OF SEPT 4	SEPT 18.	N/A	5
	A/F	25AUG87	[17]	[17SEP87]																			
052200 INSTALL TELEPHONE LINES		02SEP87	3	04SEP87								S	I	F						ACTIVITY COMPLETE		N/A	0
	A/F									S		F											
052300 INSTALL CABLEVISION LINES		02SEP87	3	04SEP87								S	I	F						ACTIVITY COMPLETE		N/A	0
	A/F									S		F											
OTHER WORK																							
	A/F																						

Figure 2-34 Introduction of Field Update Format.

LOCATION / ACTIVITY		Start	Dur	Finish	AUG 24	AUG 25	AUG 26	AUG 27	AUG 28	AUG 31	SEP 1	SEP 2	SEP 3	SEP 4	SEP 8	SEP 9	SEP 10	SEP 11	SEP 14	REMARKS	Complet.	TS	TT
072200 ELEVATOR DOOR MASONRY		09SEP87	4	14SEP87							S		F			S	X	X	F	BASEMENT YET TO BE DONE MUST BUILD ELEV. 'A' FIRST.		N/A	0
	A/F																						
122100 ELEVATOR RAILS		26AUG87	5	01SEP87	S	X	F															N/A	100
	A/F	24AUG87	3	26AUG87																ACTIVITY COMPLETE			
122300 ELEVATOR PLATFORM		27AUG87	5	02SEP87				S	X	X	X	F								ACTIVITY COMPLETE		N/A	0
	A/F																						
122500 SET ELEVATOR DOOR FRAMES		03SEP87	3	08SEP87									S	X	F					BASEMENT YET TO BE DONE MUST BUILD ELEV. CAR FIRST.		N/A	0
	A/F																						
637500 VACUUM SYSTEM ROUGH-IN		25AUG87	10	08SEP87	S	X	F															N/A	100
	A/F	24AUG87	3	26AUG87																ACTIVITY COMPLETE			
637700 INSTALL FIREPLACE INSERTS		02SEP87	[illegible]	03SEP87								S	F							NOT STARTED AS OF SEPT 4	SEPT 18.	N/A	0
	A/F		3-4																				
680200 START TEL/CABLE LINE INSTLN		02SEP87		02SEP87								S								CLARIFY THIS ACTIVITY			
	A/F																						
PK PARKING																							
5130PK MECHANICAL ROOM		27AUG87	40	23OCT87				S	X	X	X	X	X	X	X	X	X	X	X	ONGOING	OCT 8.	N/A	0
	A/F																						
GROUND FLOOR																							
7102MM INSULATION		08SEP87	1	08SEP87									S							ONGOING.	SEPT 10	N/A	0
	A/F																						
6171MM DRYWALL		10SEP87	4	15SEP87											S		S	X	X	NOT STARTED - AS OF SEPT 4		N/A	0
	A/F																						
2 2ND FLOOR																							
151502 PLUMBING ROUGH-IN		20AUG87	3	24AUG87																ACTIVITY COMPLETED.		N/A	100
	A/F	17AUG87	1	17AUG87																			
710202 INSULATION		09SEP87	1	09SEP87												S				ONGOING		N/A	0
	A/F																						
617102 DRYWALL		10SEP87	4	15SEP87													S	X	X	START OK.		N/A	0
	A/F																						
3 3RD FLOOR																							
151503 PLUMBING ROUGH-IN		25AUG87	3	27AUG87	X	X	X	F												ACTIVITY COMPLETE.		N/A	80
	A/F	18AUG87	(8)	(27AUG87)																			
OTHER WORK																							
FILL HOLES	A/F										S			F						ACTIVITY COMPLETE			
	A/F																						
	A/F																						

Why wasn't 161503 on here?

Figure 2-34 (cont'd)

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	M AUG 24	T AUG 25	W AUG 26	T AUG 27	F AUG 28	M AUG 31	T SEP 1	W SEP 2	T SEP 3	F SEP 4	T SEP 8	W SEP 9	T SEP 10	F SEP 11	M SEP 14	REMARKS	Forecast Complet.	IS	ZI
510203 DRYER AND TOILET DUCTS		24AUG87	2	25AUG87																ACTIVITY COMPLETE		N/A	100
	A/F	18AUG87	1	18AUG87																			
710203 INSULATION		10SEP87	1	10SEP87													S			START - OK		N/A	0
	A/F																						
4 4TH FLOOR *																							
✓ 151504 PLUMBING ROUGH-IN		28AUG87	3	01SEP87	0	0	0	F												ACTIVITY COMPLETE		N/A	80
	A/F	18AUG87	[8]	[27AUG87]																			
✓ 161504 ELECTRICAL WIRING/ROUGH-IN		28AUG87	3	01SEP87					S	0	F									ACTIVITY COMPLETE		N/A	0
	A/F																						
510204 DRYER AND TOILET DUCTS		26AUG87	2	27AUG87																ACTIVITY COMPLETE		N/A	100
	A/F	18AUG87	1	18AUG87																			
710204 INSULATION		11SEP87	1	11SEP87														S		START - OK		N/A	0
	A/F																						
5 5TH FLOOR																							
✓ 151505 PLUMBING ROUGH-IN		02SEP87	3	04SEP87	0	0	0	F												ACTIVITY COMPLETE		N/A	80
	A/F	19AUG87	[7]	[27AUG87]																			
✓ 161505 ELECTRICAL WIRING/ROUGH-IN		02SEP87	3	04SEP87								S	0	F						ACTIVITY COMPLETE		N/A	0
	A/F																						
510205 DRYER AND TOILET DUCTS		28AUG87	2	31AUG87																ACTIVITY COMPLETE		N/A	100
	A/F	19AUG87	1	19AUG87																			
710205 INSULATION		14SEP87	1	14SEP87															S	START - OK		N/A	0
	A/F																						
6 6TH FLOOR *																							
✓ 151506 PLUMBING ROUGH-IN		08SEP87	3	10SEP87	0	0	0	F												ACTIVITY COMPLETE		N/A	80
	A/F	20AUG87	[6]	[27AUG87]																			
161506 ELECTRICAL WIRING/ROUGH-IN		08SEP87	3	10SEP87											S	0	F			ON HOLD - DESIGN CHANGE		N/A	0
	A/F																						
510206 DRYER AND TOILET DUCTS		01SEP87	2	02SEP87																ACTIVITY COMPLETE		N/A	100
	A/F	20AUG87	1	20AUG87																			
PH/LOWER.PH/																							
✓ 1515PL PLUMBING ROUGH-IN		11SEP87	3	15SEP87	0	0	0	F												ACTIVITY COMPLETE		N/A	80
	A/F	21AUG87	[5]	[27AUG87]																			
OTHER WORK																							
EARTH[illegible] FRAMING —	A/F																			ACTIVITY COMPLETE			
WOOD BACKING —	A/F																			ACTIVITY COMPLETE			
[illegible]	A/F																			ACTIVITY [illegible]			

Figure 2-34 (cont'd)

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	M AUG 24	T AUG 25	W AUG 26	T AUG 27	F AUG 28	M AUG 31	T SEP 1	W SEP 2	T SEP 3	F SEP 4	T SEP 8	W SEP 9	T SEP 10	F SEP 11	M SEP 14	REMARKS	Forecast Complet.	%S	%I
✓ 1615PL ELECTRICAL WIRING/ROUGH-IN		11SEP87	3	15SEP87														●	X		SEPT 11	N/A	0
	A/F														S								
5102PL DRYER AND TOILET DUCTS ✓		03SEP87	2	04SEP87	X	X	X	●														N/A	50
	A/F	21AUG87	(5)	[27AUG87]														F					
✓ 6151PL EXTERIOR STUD SHEATHING		27AUG87	3	31AUG87				S	X	●												N/A	0
	A/F										✓	✓	✓	✓	✓	F							
[illegible] PU																							
✓ 1515PU PLUMBING ROUGH-IN		28AUG87	3	01SEP87					S	X	F									ACTIVITY COMPLETE		N/A	0
	A/F																						
✓ 1611PU ELECTRICAL RISERS		24AUG87	1	24AUG87	S																	N/A	100
	A/F	24AUG87	1	24AUG87																ACTIVITY COMPLETE			
✓ 5102PU DRYER AND TOILET DUCTS		28AUG87	2	31AUG87					S	●												N/A	0
	A/F										✓	✓	✓	✓	✓	✓	✓	F					
✓ 7222PU STEEL FRAMING - PENTHOUSE		28JUL87	5	04AUG87	X	F																N/A	95
	A/F	05AUG87	15	25AUG87																ACTIVITY COMPLETE			
6151PU EXTERIOR STUD SHEATHING		01SEP87	3	03SEP87							S	X	●		F							N/A	0
	A/F																						
RF ROOF																							
7221RF METAL DECKING		27AUG87	5	02SEP87				S	X	X	X	●		F								N/A	0
	A/F																						
OTHER WORK																							
	A/F																						
	A/F																						

Why isn't 1615 PL on?. (not in time frame?)

Figure 2-34 (cont'd)

RS discovers that application for a sewer/water connection permit was never made. This will delay water inspections.

Poor performance by exterior enclosure subs is becoming progressively more obvious. Significant undermanning of job is occurring. Emphasis on always selecting the lowest priced sub and the current hot market creates difficulty (as well, the small job size does not help).

Design details are still unfolding - e.g. security system.

All during this time the project is blessed with superb weather. Subtrades fail to capitalize on it.

View of RS is that the project manager should sit down with the sub at the time the contract is signed and discuss the duration of the work for each activity and crew size. The problem is project managers in general don't have enough detailed knowledge of each trade to define activities accurately, including manning levels and production rates. Further, even if it could be done, how do you enforce rates and levels?

During this period, there is a continued refinement of activities, logic and durations. RS is now becoming concerned with the conditions that must be met to obtain an occupancy permit.

Implications of current subtrade strategies (at least those that are discernible) discussed with JM. In particular, the plan of the enclosure stucco sub to scaffold a face of the building at a time and rotate scaffolding, to save money. ADR points out to JM that this will not allow waterproofing of main slab at street level until November, the rainy season. This discussion leads to a change in scaffolding strategy, with additional money being given to trade to scaffold all faces. The benefit of this strategy is lost, as the stucco sub continues to underman the job. Waterproofing still pushed to November. Superb fall weather opportunity wasted.

More problems with architectural details encountered. But JM can't complain very strongly to owner because of power of the architect to recommend the firm to future owners.

An observation at this stage is the need to archive monthly schedules and develop ability to overlay them to detect reasons for delays. Important for dealing with subs, especially for backcharging.

Subdividing of activities starts to appear - i.e. requiring subtrades to make multiple passes through building in order to maintain pace and work around problems.

The location sequence for finishing work is still MN - PU.

September 14, 1987 Schedule - Progress as of September 8

Much better feedback now being received from field. RS completing field update report - see figure 2-34. Information used to revise schedule and produce new forecast completion of December 11, 1987 (see figure 2-35). Revised schedule issued with field update report (figure 2-36).

Feedback as identified on figure 2-36 includes the following.

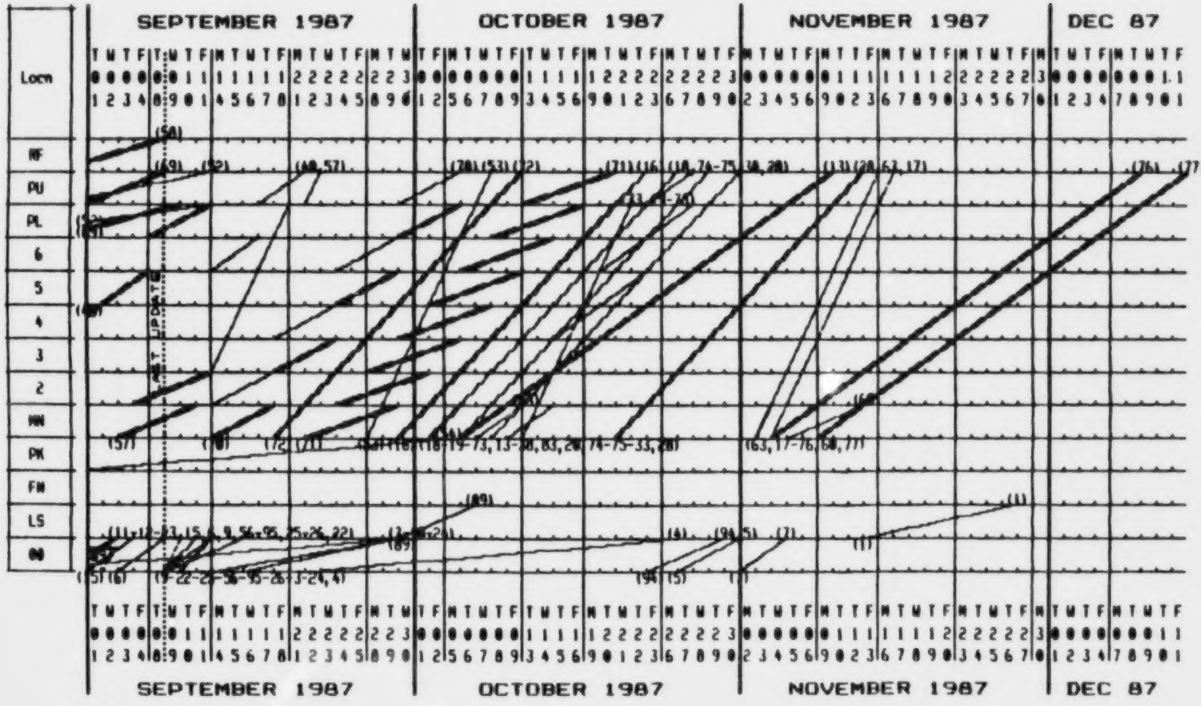
> Activities associated with vestibules on all 7 floors identified - framing, gyproc, tape and fill - another example of a multiple pass operation required by a subtrade because design details not known.
>
> Other activities added include waterproofing patio decks, all chimney related work - framing (10 days), gyproc(10 days), ductwork(2 days) and stucco(4 days). The chimney work becomes important later on because of extensive delays. Actual durations are, respectively, 15, 24, 4.

TIFFANY PLACE (43RD & YEW)

LINEAR PLANNING CHART

```
+------------------------------+
K | *  critical act.            |
E | p  act. has procurement seq. |
Y | c  completed                 |
+------------------------------+
```

Report Date : 1987-09-14
Report Time : 19:20:10
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
Progress as of : 1987-09-08
Schedule Window
From 01SEP87 To 11DEC87
From LS To RF

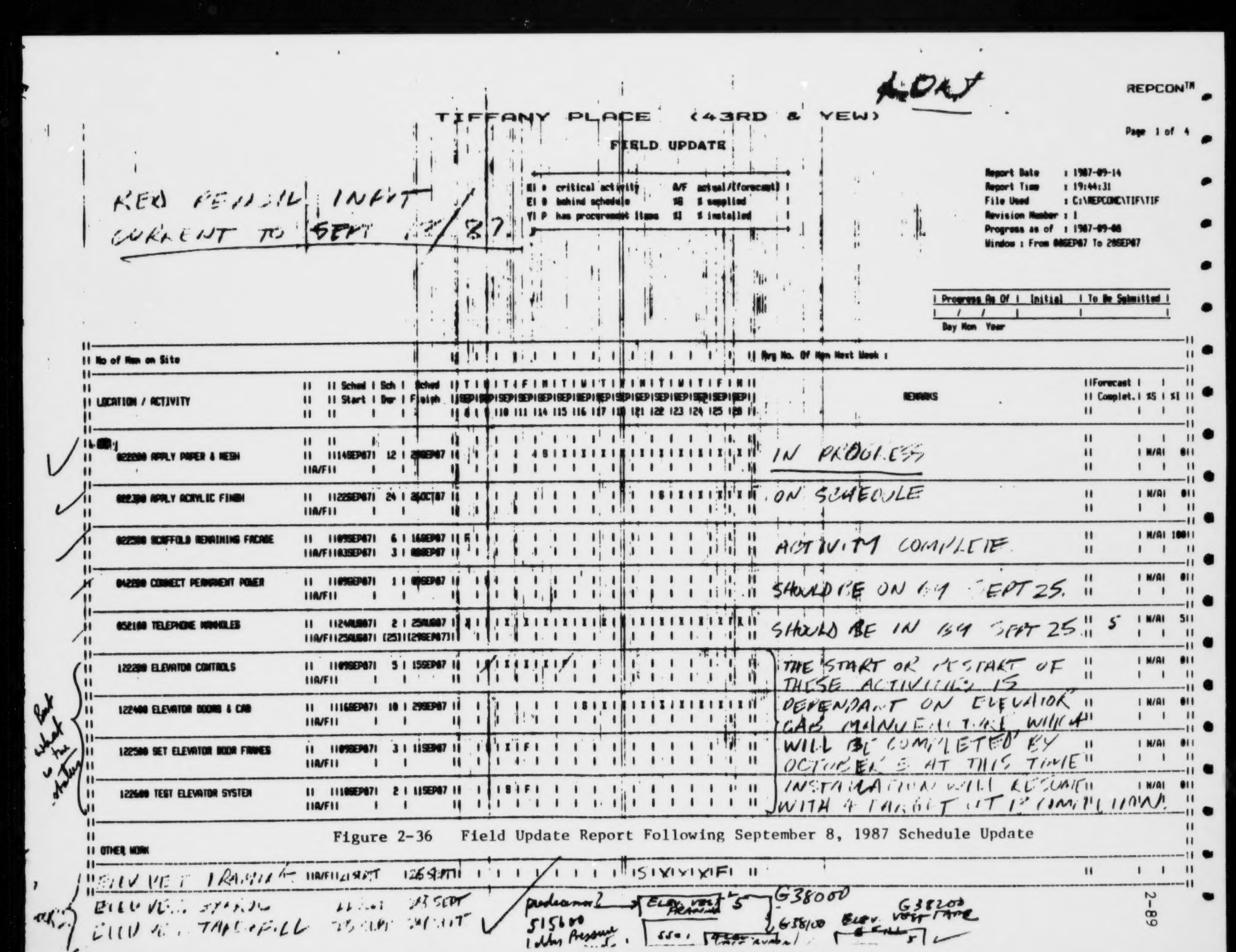


ACTIVITY KEY

	Act No	Type	Act Description
(1)	0121LS		LANDSCAPING
(3)	022200		APPLY PAPER & MESH
(4)	022300		APPLY ACRYLIC FINSH
(5)	022400		CAULK WINDOWS
c(6)	022500		SCAFFOLD REMAINING FACADE
(7)	023700		REMOVE SCAFFOLDING
(9)	042200		CONNECT PERMANENT POWER
(10)	052100		TELEPHONE MANHOLES
c(11)	052200		INSTALL TELEPHONE LINES
c(12)	052300		INSTALL CABLEVISION LINES
*(13)	060100	N	KITCHEN/BATHROOM CABINETS
c(15)	072200		ELEVATOR DOOR MASONRY
*(16)	100100	N	PAINT UNDER/PRIMER/FINSH COATS
(17)	100200	N	PAINT TOUCH-UP
(18)	110100	N	INSTALL CERAMIC TILES
(19)	110200	N	INSTALL MARBLE ENTRANCES
(20)	110300	N	INSTALL TILE BALCONIES
(22)	122200		ELEVATOR CONTROLS
c(23)	122300		ELEVATOR PLATFORM
(24)	122400		ELEVATOR DOORS & CAB
(25)	122500		SET ELEVATOR DOOR FRAMES
(26)	122600		TEST ELEVATOR SYSTEM
*(28)	150300	N	PLUMBING FINISHING
(33)	151000	N	FIRE CABINET HOSES/COVERS
(38)	160300	N	ELECTRICAL FINISHING/FIXTURES
*(40)	161500	N	ELECTRICAL WIRING/ROUGH-IN
(52)	510200	N	DRYER AND TOILET DUCTS
*(53)	510500	N	VENTILATION FINISHING
(54)	5130PK		MECHANICAL ROOM
(56)	515600		LOBBY VENT PRESSURE DUCTS
*(57)	710200	P	INSULATION
*c(58)	7221RF		METAL DECKING
(60)	737300		WATERPROOFING EXT. MAIN SLAB
*(63)	920100	N	CARPETING
*(69)	615100	N	EXTERIOR STUD SHEATHING
*(70)	617100	N	DRYWALL
*(71)	617200	S	GYPSUM JOINTS
*(72)	617300	N	PLASTER CEILING
*(73)	617400	N	HARDWOOD FLOORING
(74)	618000	N	FINISH CARPENTRY
(75)	618100	N	HARDWARE FINISHING
*(76)	619000	N	CLEAN APARTMENTS

	Act No	Type	Act Description
(83)	6207MN		BACKFILL AROUND PERIMETER
(89)	6260LS		DRIVEWAY
(94)	637600		INSTALL VACUUM UNITS/TEST
(95)	637700		INSTALL FIREPLACE INSERTS
*(97)	680200		START TEL/CABLE LINE INSTLN

Figure 2-35 September 8, 1987
Schedule Update



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TIFFANY PLACE (43RD & YEW)

FIELD UPDATE

Page 1 of 4

RED PENCIL INPUT CURRENT TO SEPT 1?/87.

- E! ● critical activity — A/F actual/(forecast)
- E! B behind schedule — $S % supplied
- Y! P has procurement items — $I % installed

Report Date : 1987-09-14
Report Time : 19:44:31
File Used : C:\REPCONE\TIF\TIF
Revision Number : 1
Progress as of : 1987-09-08
Window : From 08SEP87 To 28SEP87

Progress As Of	Initial	To Be Submitted
/ /		

Day Mon Year

No of Men on Site — Avg No. Of Men Next Week :

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	T SEP 8	W SEP 9	T SEP 10	F SEP 11	M SEP 14	T SEP 15	W SEP 16	T SEP 17	F SEP 18	M SEP 21	T SEP 22	W SEP 23	T SEP 24	F SEP 25	M SEP 28	REMARKS	Forecast Complet.	%S	%I
022200 APPLY PAPER & MESH		14SEP87	12	29SEP87					S	X	X	X	X	X	X	X	X	X	X	IN PROGRESS		N/A	0
	A/F																						
022300 APPLY ACRYLIC FINISH		22SEP87	24	26OCT87											S	X	X	X	X	ON SCHEDULE		N/A	0
	A/F																						
022500 SCAFFOLD REMAINING FACADE		09SEP87	6	16SEP87	A															ACTIVITY COMPLETE		N/A	100
	A/F	03SEP87	3	08SEP87																			
042200 CONNECT PERMANENT POWER		09SEP87	1	09SEP87		4														SHOULD BE ON BY SEPT 25.		N/A	0
	A/F																						
052100 TELEPHONE MANHOLES		24AUG87	2	25AUG87	X		X	X	X	X	X	X	X	X	X	X	X	X	X	SHOULD BE IN BY SEPT 25	5	N/A	5
	A/F	25AUG87	(25)	(29SEP87)																			
122200 ELEVATOR CONTROLS		09SEP87	5	15SEP87		S	X	X	X	F										THE START OR RESTART OF THESE ACTIVITIES IS DEPENDANT ON ELEVATOR CAB MANUFACTURE WHICH WILL BE COMPLETED BY OCTOBER 5 AT THIS TIME INSTALLATION WILL RESUME WITH A TARGET OF [illegible] COMPLETION.		N/A	0
	A/F																						
122400 ELEVATOR DOORS & CAB		16SEP87	10	29SEP87							S	X	X	X	X	X	X	X	X			N/A	0
	A/F																						
122500 SET ELEVATOR DOOR FRAMES		09SEP87	3	11SEP87		S	X	F														N/A	0
	A/F																						
122600 TEST ELEVATOR SYSTEM		10SEP87	2	11SEP87			S	F														N/A	0
	A/F																						

But what is the status

Figure 2-36 Field Update Report Following September 8, 1987 Schedule Update

OTHER WORK

ELEV VEST FRAMING	A/F	21SEPT		26SEPT										S	X	X	X	F	
ELEV VEST STANDING		22 SEPT		23 SEPT															
ELEV VEST TAPE & FILL		25 SEPT		26 SEPT															

predecessor? → ELEV VEST FRAMING 5 → G38000

515600 lobby pressure

550

G38100 ELEV. VEST

G38200 ELEV. VEST TAPE & FILL 5

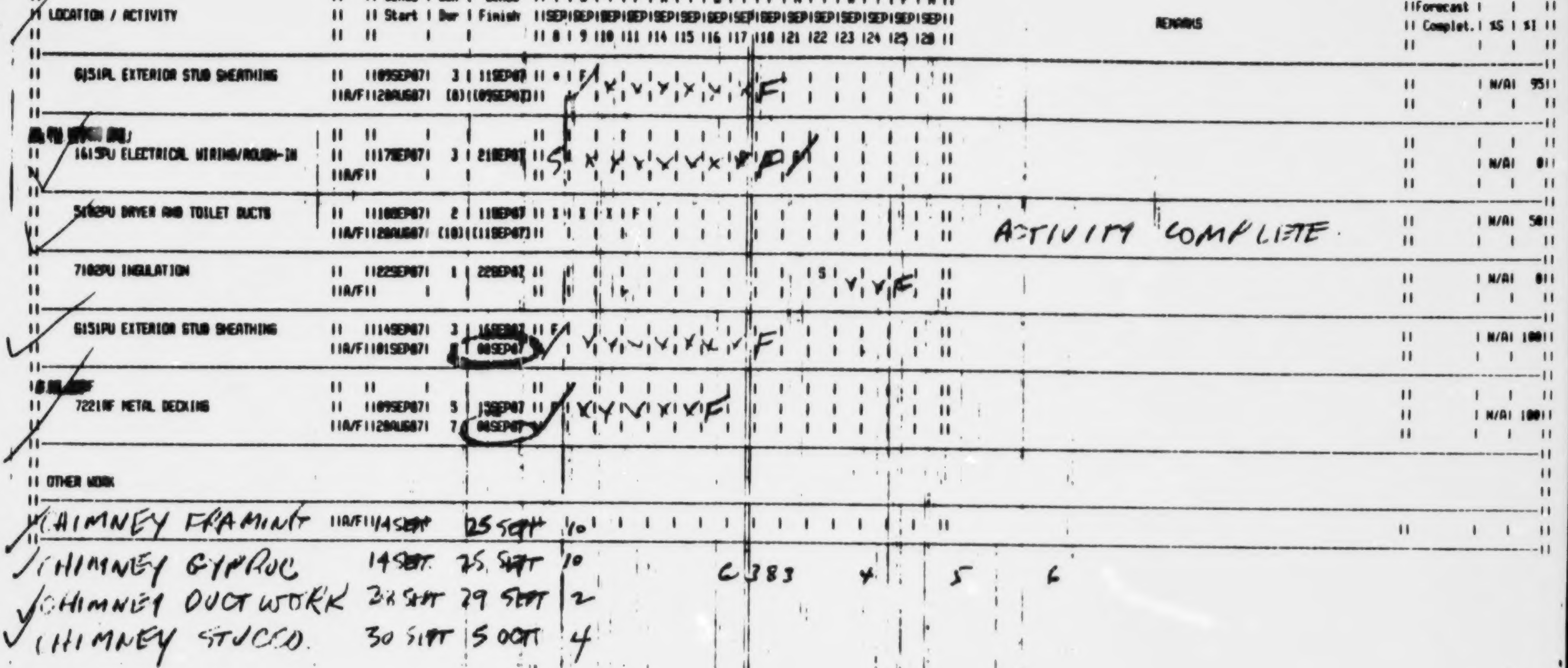
LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	T SEP 8	W SEP 9	T SEP 10	F SEP 11	M SEP 14	T SEP 15	W SEP 16	T SEP 17	F SEP 18	M SEP 21	T SEP 22	W SEP 23	T SEP 24	F SEP 25	M SEP 28	REMARKS	Forecast Complet.	%S	%I
515600 LOBBY VENT PRESSURE DUCTS	 A/F	09SEP87	2	10SEP87		S	F		F											ACTIVITY/ COMPLETE		N/A	0
637700 INSTALL FIREPLACE INSERTS	 A/F	09SEP87	2	10SEP87		S	F															N/A	0
[illegible]																							
5130PK MECHANICAL ROOM	 A/F	09SEP87 31AUG87	40 (24)	04NOV87 [02OCT87]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	ON GOING. Has to follow plumbing		N/A	10
[illegible] FLOOR																							
5105AN VENTILATION FINISHING	 A/F	28SEP87	1	28SEP87															S	ACTIVITY WILL START AFTER ALL WALL FINISHES COMPLETE		N/A	0
7102AN INSULATION	 A/F	16SEP87 03SEP87	1 (5)	16SEP87 [10SEP87]	*	*	F													ACTIVITY COMPLETE		N/A	50
6171AN DRYWALL	 A/F	14SEP87	4	17SEP87					S	*	*	F	X	X	X	F						N/A	0
6172AN GYPSUM JOINTS	 A/F	22SEP87	6	29SEP87											S	*	S	*	*			N/A	0
6173AN PLASTER CEILING	 A/F	18SEP87	2	21SEP87									S	F					S			N/A	0
[illegible]																							
710202 INSULATION	 A/F	17SEP87 04SEP87	1 (5)	17SEP87 [11SEP87]	*	*	*	F												ACTIVITY COMPLETE		N/A	0
617102 DRYWALL	 A/F	14SEP87	4	17SEP87					S	X	X	F								ACTIVITY COMPLETE		N/A	0
617202 GYPSUM JOINTS	 A/F	24SEP87	6	01OCT87													S	*	*	ON GOING		N/A	0
617302 PLASTER CEILING	 A/F	22SEP87	2	23SEP87							S	F X	X	F								N/A	0
[illegible] 2ND FLOOR																							
710203 INSULATION	 A/F	14SEP87	1	14SEP87		S	X	X	F											ACTIVITY COMPLETE.		N/A	0
617103 DRYWALL	 A/F	18SEP87	4	23SEP87					S	X	F		S	*	*	F				ACTIVITY COMPLETE		N/A	0
OTHER WORK																							
	A/F																						
	A/F																						
	A/F																						

Figure 2-36 (cont'd)

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	T SEP 8	W SEP 9	T SEP 10	F SEP 11	M SEP 14	T SEP 15	W SEP 16	T SEP 17	F SEP 18	M SEP 21	T SEP 22	W SEP 23	T SEP 24	F SEP 25	M SEP 28	REMARKS	Forecast Complet.	%S	%I
617203 GYPSUM JOINTS	 A/F	28SEP87	6	05OCT87								S	X	X	X	F			S	ON GOING		N/A	
617303 PLASTER CEILING	 A/F	24SEP87	2	25SEP87													S	X	X			N/A	
[redacted]																							
161504 ELECTRICAL WIRING/ROUGH-IN	 A/F	10SEP87 28AUG87	3 3	14SEP87 01SEP87	F															ACTIVITY COMPLETE		N/A	
710204 INSULATION	 A/F	15SEP87	1	15SEP87			S	X	X	F										ACTIVITY COMPLETE		N/A	
617104 DRYWALL	 A/F	18SEP87	4	23SEP87						S	X	F	✓	✓	✓	✓				ACTIVITY COMPLETE		N/A	
617304 PLASTER CEILING	 A/F	28SEP87	2	29SEP87												S	X	X	F			N/A	
[redacted]																							
161505 ELECTRICAL WIRING/ROUGH-IN	 A/F	15SEP87 02SEP87	3 3	17SEP87 04SEP87		F														ACTIVITY COMPLETE		N/A	
710205 INSULATION	 A/F	16SEP87	1	16SEP87				S	X	X	F									ACTIVITY COMPLETE		N/A	
617105 DRYWALL	 A/F	24SEP87	4	29SEP87							S	X	F				✓	✓	✓	ACTIVITY COMPLETE		N/A	
[redacted]																							
161506 ELECTRICAL WIRING/ROUGH-IN	 A/F	14SEP87	3	16SEP87					S	X	F									ACTIVITY COMPLETE		N/A	
710206 INSULATION	 A/F	17SEP87	1	17SEP87								✓	S	X	X	F						N/A	
617106 DRYWALL	 A/F	24SEP87	4	29SEP87													S	X	X			N/A	
[redacted]																							
1615PL ELECTRICAL WIRING/ROUGH-IN	 A/F	23SEP87 08SEP87	3 (4)	25SEP87 (11SEP87)	S	•	•	X	X	X	X	X	X	F								N/A	
7102PL INSULATION	 A/F	18SEP87	1	18SEP87									✓		S	X	X	F				N/A	
OTHER WORK																							
[illegible]	A/F	15 SEPT		17SEPT						S	X	F								ACTIVITY [illegible]			
	A/F																						
	A/F																						

MIC [illegible] [illegible] WORK IN THIS TIME LAPSE *

Figure 2-36 (cont'd)



LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	T SEP 8	W SEP 9	T SEP 10	F SEP 11	M SEP 14	T SEP 15	W SEP 16	T SEP 17	F SEP 18	M SEP 21	T SEP 22	W SEP 23	T SEP 24	F SEP 25	M SEP 28	REMARKS	Forecast Complet.	$S	$I
6J51PL EXTERIOR STUB SHEATHING	 A/F	09SEP87 28AUG87	3 (8)	11SEP87 (09SEP87)	•	F	X	Y	Y	X	Y	X	F									N/A	95
[redacted] 1615PU ELECTRICAL WIRING/ROUGH-IN	 A/F	17SEP87	3	21SEP87	S	X	Y	Y	X	V	V	X	P									N/A	0
5102PU DRYER AND TOILET DUCTS	 A/F	10SEP87 28AUG87	2 (10)	11SEP87 (11SEP87)	X	X	X	F												ACTIVITY COMPLETE		N/A	50
7102PU INSULATION	 A/F	22SEP87	1	22SEP87											S	Y	Y	F				N/A	0
6151PU EXTERIOR STUB SHEATHING	 A/F	14SEP87 01SEP87	3 8	16SEP87 08SEP87	F		Y	Y	V	Y	Y	X	F									N/A	100
[redacted] 7221MF METAL DECKING	 A/F	09SEP87 28AUG87	5 7	15SEP87 08SEP87		X	Y	N	X	V	F											N/A	100
OTHER WORK																							
CHIMNEY FRAMING	A/F	14SEPT	10	25 SEPT																			

CHIMNEY GYPROC 14SEPT 25 SEPT 10 C 383 4 5 6

CHIMNEY DUCTWORK 28 SEPT 29 SEPT 2

CHIMNEY STUCCO. 30 SEPT 5 OCT 4

* NOTE. EXTERIOR FINISHES SHOULD BE MORE CLOSELY TIED INTO WEEKLY SCHEDULE UPDATE, BY FACE OF BUILDING.

EAST FACE START 14 SEPT BASE COAT STUCCO - FINISH 18 SEPT

START 21 SEPT FINISH COAT (COLOUR) FINISH 23

START 29 SEPT CAULKING FINISH 25

START 25 CLEAN WINDOWS FINISH 25.

INSTALL RAIN WATER LEADERS (WHEN [illegible])

START 25 REMOVE SCAFFOLD FINISH 30.

MOVING [illegible] TO SOUTH, THEN NORTH, THEN WEST

([illegible] A [illegible] 6-7 MAN CREW)

Figure 2-36 (cont'd)

More and more attention is being given to manpower levels - major cause of delay as tradesmen being shuffled from project to project by subtrades, in part because details on the project are not resolved.

The location sequence for finishing activities is still MN - PU.

September 24, 1987 Update - Progress as of September 18

New field update report issued to RS.

Feedback on this report shows that sequences are being broken up into multiple passes - e.g. prime bathrooms first, then do second pass for entire suite.

Some difficulty is being encountered in getting RS to record accurate start and finish dates for activities at each level. It is not an easy task - definition of start and completion of work at each location is fuzzy. The superintendent may not check every floor and/or every activity each day. So recorded actuals can be out by a day or two, especially when activities start part way through a day (or complete part way through). Time is a continuous parameter - monitoring it as a discrete event. There is no point, however, in seeking greater refinement in the time unit used- e.g. hour, quarter or half days.

The location sequence for finishing activities now changes to 2,3,4,5,MN,6,PL,PU. The main floor is being used as a storage area for material deliveries instead of the garage to permit easy access.

September 27, 1987 Field Update Report

RS completes it with progress up to October 2.

RS asks that cabinet work be broken into two passes - bathrooms, kitchens. Can't work in kitchen but can in bathrooms. Probably best to do it this way anyway.

October 4, 1987 Schedule - Progress as of October 2

The schedule as of October 2 is shown in figure 2-37. Projected completion is December 10, 1987.

This schedule incorporates feedback from the September 27 field update form. The finishing location sequence is still 2,3,4,5,MN,6,PL,PU.

Some activity durations have been changed - e.g. bathroom ceramic tile.

The strategy for painting has been changed again. Now no longer breaking bathrooms out- could not coordinate.

October 5, 1987 Site Meeting with RS

An extensive review of the October 4 schedule was made.

Marketing is now gaining momentum. The first sale has been made on the 6th floor. The owner has promised a November 1 occupancy date. Finish sequence now becomes 6,MN,2,3,4,5,PL,PU for all activities not yet started in an attempt to meet the November 1 commitment.

The decision was made to refine the treatment of finish carpentry by treating it as a three pass activity. This was important in order to properly treat coordination interfaces. The three passes were defined as follows.

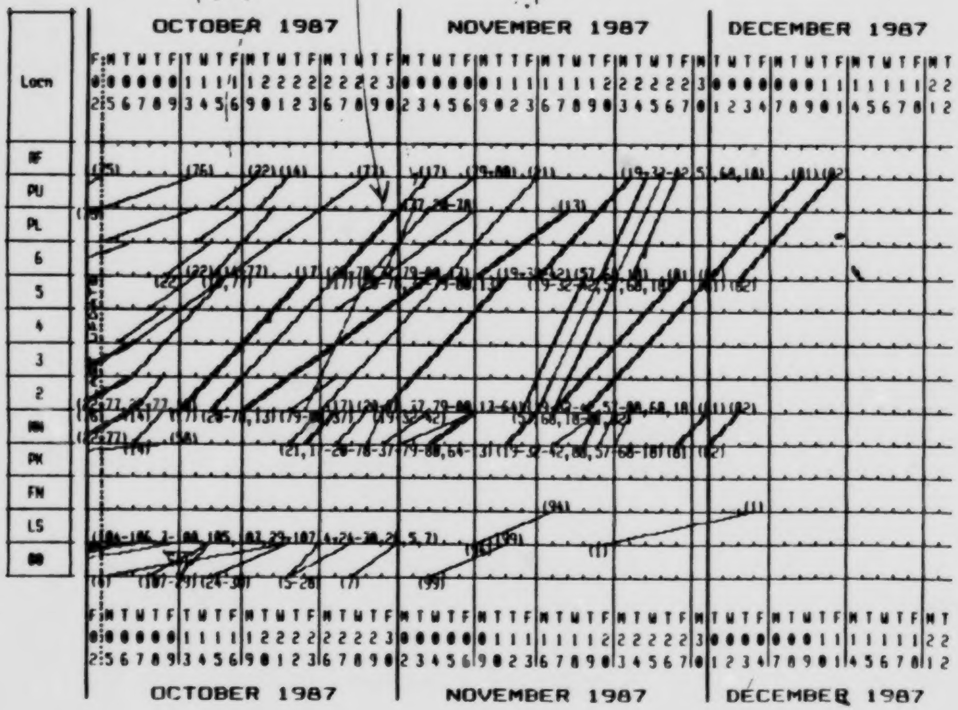
REPCON™

TIFFANY PLACE (43RD & YEW)

LINEAR PLANNING CHART

```
+---------------------------------+
K | *   critical act.               |
E | p   act. nas procurement seq.   |
Y | c   completed                   |
+---------------------------------+
```

Report Date : 1987-10-04
Report Time : 12:02:02
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
Progress as of : 1987-10-02
Schedule Window
From 02OCT87 To 22DEC87
From LS To RF



Some finish carpentry must go before this

change sequence

Figure 2-37 October 2, 1987 Schedule Update.

ACTIVITY KEY

Act No		Type	Act Description
(1)	0121LS		LANDSCAPING
(3)	022200		APPLY PAPER & MESH
(4)	022300		APPLY ACRYLIC FINSH
(5)	022400		CAULK WINDOWS
(7)	023700		REMOVE SCAFFOLDING
*(13)	060100	N	KITCHEN CABINETS
(14)	060200	S	BATHROOM VANITIES
*(17)	100100	N	PAINT UNDER/PRIMER/FINSH COATS
(18)	100200	N	PAINT TOUCH-UP
*(19)	110100	N	KITCHEN CERAMIC TILES
(20)	110200	N	INSTALL MARBLE ENTRANCES
(21)	110300	N	INSTALL TILE BALCONIES
*(22)	110400	N	BATHROOM CERAMIC TILE
(24)	122200		ELEVATOR CONTROLS
(28)	122600		TEST ELEVATOR SYSTEM
(29)	122700		INSTALL ELEVATOR CAB
(30)	122800		ADJUST ELEVATOR DOORS
(32)	150300	N	PLUMBING FINISHING
(37)	151800	N	FIRE CABINET HOSES/COVERS
(42)	160300	N	ELECTRICAL FINISHING/FIXTURES
*(57)	510500	N	VENTILATION FINISHING
(58)	5130PK		MECHANICAL ROOM
(64)	7373MM		WATERPROOFING EXT. MAIN SLAB
*(68)	920100	N	CARPETING
*c(75)	617100	N	DRYWALL
*(76)	617200	S	GYPSUM JOINTS
(77)	617300	N	PLASTER CEILING
*(78)	617400	N	HARDWOOD FLOORING
(79)	618000	N	FINISH CARPENTRY
(80)	618100	N	HARDWARE FINISHING
*(81)	619000	N	CLEAN APARTMENTS
*(82)	619100	N	APARTMENT DEFICIENCIES
(88)	G207MM		BACKFILL AROUND PERIMETER
(94)	G260LS		DRIVEWAY
(99)	637600		INSTALL VACUUM UNITS/TEST
(103)	638200		ELEVATOR VESTIBULE TAPE/FILL
c(104)	638300		CHIMNEY FRAMING
(105)	638400		CHIMNEY GYPROC
c(106)	638500		CHIMNEY DUCTWORK
(107)	638600		CHIMNEY STUCCO
(108)	638700		METAL HANDRAILS-STAIRWELL
*(111)	[illegible]		ELEVATOR CAB ONSITE

Finish Carpentry I: Wood trims, Pre-hung doors, Pocket doors, Casings, Baseboards, Metal doors and hardware.

Finish Carpentry II: Bifold tracks, Bipass tracks, Steel door hardware and suite interiors.

Finish Carpentry III: Bifold doors, Bipass (sliding) doors.

Other observations include the following.

Hardwood floor finish is to be a 3 coat system: filler (1 day); rough and fine sanding (1 day); sealer (1 day); glittza (1 day).

Activities to treat balcony and handrails and handrail glazing for all floors are added. As per other activities, it turns out that it is better to treat activities at the locations they occur, even if the total elapsed duration for the activity for all locations is small. The reason given is that difficulties are often encountered at a specific level. They may have to be temporarily bi-passed. Also, want to be able to track deficiencies floor by floor.

At this juncture, RS is relying heavily on the schedule and is attempting to use it as a major check list. So he wants to add more and more detail.

ADR estimates that a month has been lost because sub contracts awarded late and detailed planning and consultation with subs did not take place early enough (e.g. July). To verify this assertion, a listing of contract award dates to various subtrades was compiled as shown below (S&I refers to supply and install). Part of the problem associated with the late letting of contracts (and hence procurement delays) was that finishes were not selected early enough by the architect and owner.

Award Dates of Subcontracts

1. Shoring, shotcrete, rock anchors	12 March 87
2. Excavation	16 March 87
3. Elevator	16 March 87
4. Mechanical (plumbing, sheet metal, fans, gas, sprinklers)	8 April 87
5. Sand, gravel, drain rock	15 April 87
6. S&I Reinforcing steel	12 May 87
7. Supply shoring for formwork	9 June 87
8. Electrical	11 June 87
9. S&I Built in vacuum cleaner	24 June 87
10. S&I Video intercom system	15 July 87
11. S&I Garage door	21 July 87
12. Metal Roofing	23 July 87
13. S&I Windows and patio doors	5 August 87
14. S&I Drywall	5 August 87
15. S&I Waterproofing membrane	20 August 87
16. Drapery track and sheers	28 Sept 87
17. S Doors and hardware	28 Sept 87
18. Landscaping	28 Sept 87
19. Gas fire places	28 Sept 87
20. Flooring (hardwood,carpeting,vinyl)	8 Oct 87
21. Paint and wallpaper	8 Oct 87
22. S&I Closet organizers	6 Nov 87

RS is focusing on what must be done to obtain the various occupancy permits. Wants the details described below incorporated into the schedule.

Occupancy Permit

```
Install Perm. Power -->
          Remove Temp. Power Box -->
                                 Backfill -->
                                      Gas Meter Connect. -->
                                                   Occupancy Permit
```

Shell Occupancy Permit

```
I. Sprinkler System & Fire              -------->|
   cabinets                                      |
                                                 |
II. Mechanical systems                           |
   - air pressurization system              ---->|
   - sump pumps                             ---->|
   - rainwater leaders                      ---->|
   - gas line & meter                       ---->|---> Shell Occupancy
                                                 |          Permit
III. Balcony handrails & glazing            ---->|
                                                 |
IV. Electrical Systems                           |
   - emergency generators                   ---->|
   - fire alarm system                      ---->|
   - public lighting                   --------->|
```

For activity groupings I, II and IV to be complete, systems must be inspected and signed off by City Hall. The consultants must prepare and file letters of completion with the city.

Final Elevator Permit

In order to obtain the final elevator permit, the integration of the elevator system with fire, lighting, etc., systems must be checked out.

```
Fire Alarm                 ---------------->|
                                            |
Lighting                   ---------------->|---> Final Elevator Permit
                                            |
Public Area Floor          ---------------->|
   finishes
```

At this time it was clear that the expenditure on the additional scaffolding had been wasted. The stucco crew was too small to take advantage of it. Little or no overlapping between the stucco scratch coat and acrylic finish had been achieved.

Based on this meeting, significant changes were incorporated into the schedule. Revisions made to the sequence of suite finishing activities are summarized in figure 2-38. This figure contains schedule changes made later.

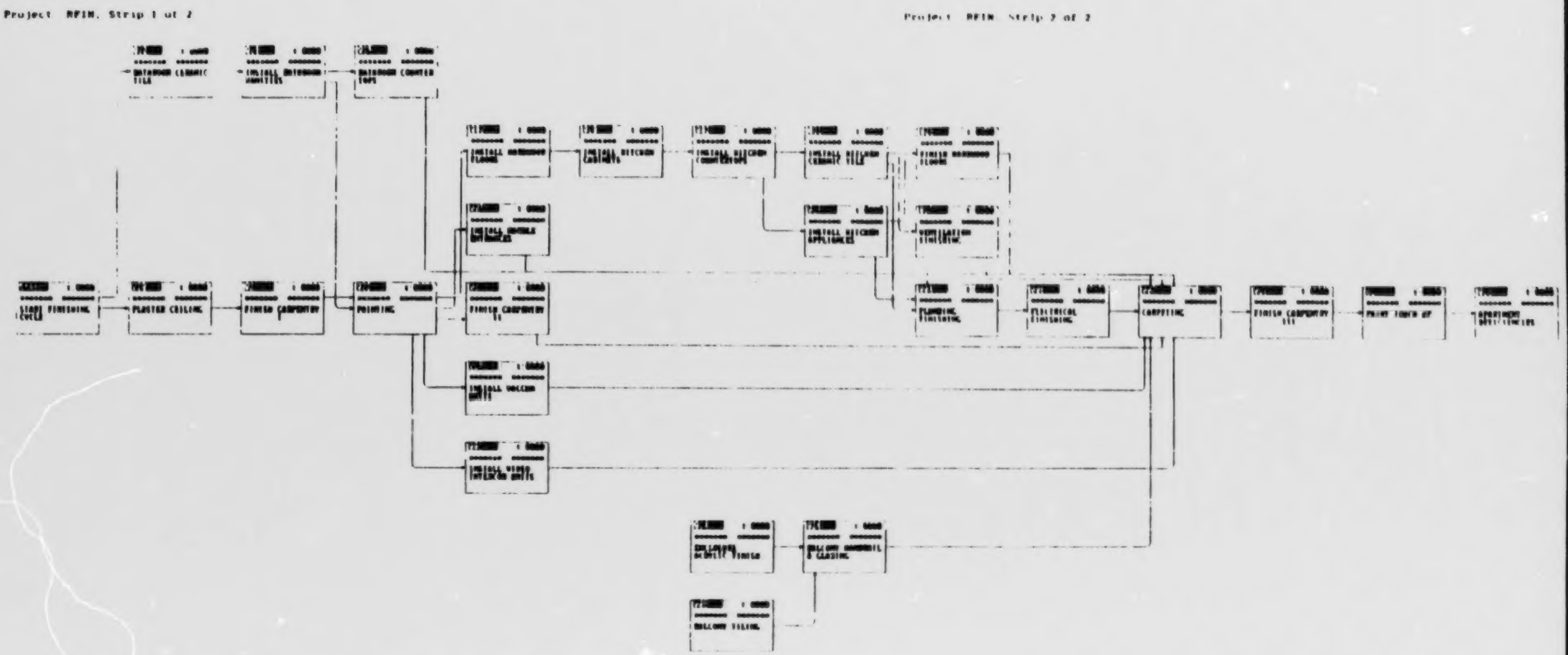

Project RFIN, Strip 1 of 2
Project RFIN, Strip 2 of 2
START FINISHING CYCLE
PLASTER CEILING
FINISH CARPENTRY I
PAINTING
BATHROOM CERAMIC TILE
INSTALL BATHROOM VANITIES
BATHROOM COUNTER TOPS
INSTALL HARDWOOD FLOORS
FINISH CARPENTRY II
INSTALL VACUUM UNITS
INSTALL VIDEO INTERCOM UNITS
INSTALL KITCHEN CABINETS
INSTALL KITCHEN COUNTERTOPS
INSTALL KITCHEN CERAMIC TILE
INSTALL KITCHEN APPLIANCES
FINISH HARDWOOD FLOORS
VENTILATION FINISHING
PLUMBING FINISHING
ELECTRICAL FINISHING
CARPETING
FINISH CARPENTRY III
PAINT TOUCH UP
APARTMENT DEFICIENCIES
BALCONY HANDRAIL & GLAZING
BALCONY TILING

Figure 2-38 Finishing Activity Sequence.

October 7, 1987 Schedule - Progress as of October 2

The findings from the October 4 meeting and the previous field update report were used to produce a major schedule revision.

The revised schedule is shown in figures 2-39 (critical activities only) and figure 2-40 (all activities). Forecast completion is now December 15, 1987. Note the change in location sequence - floor 6 is now singled out for priority treatment. Use of the special repetitive planning structures permits a speedy revision of the schedule.

Along with the revised schedule, a new field update report is issued to RS.

Over the next week, the owner abandons his commitment to have the 6th floor finished by November 1.

The completion of exterior enclosure (acrylic coat) is delayed. The architect had specified an external insulation product that is not acceptable to the city inspector because of fire considerations. In a discussion with the sub, he stated that the acrylic finish cannot be applied in the rain. Also, a 7 day curing period is required between application of the scratch stucco coat and the acrylic coat. The acrylic coat has to be applied to both sides of the balcony concrete wall and to the underside of the balcony. The balcony walls have to be ground and sacked to fill holes before the acrylic is applied. This preparatory work is not in progress but should be.

Excellent weather still ongoing. Can't remove scaffolding so main floor exterior slab over parkade can be waterproofed.

Schedule refinements continue. Continue to break sub trade work down into multiple passes. For example, tile balconies - instead of installing the three balconies per floor in one pass, now require the tile man to make two passes to accommodate exterior stucco work not being completed on all faces.

October 11, 1987 Schedule - Progress as of October 9

Updating is now being down weekly. Schedule to be updated using feedback from field update report from October 7 field update report.

The location sequence for finishing activities has again been changed, now to 6,5,4,3,2,MN,PL,PU.

RS wants new activity on marble entrances entered.

Projected completion stays at December 15, 1987. See figure 2-41 for linear planning chart for critical activities.

Updated field update report issued to RS. Review of this report when completed shows that RS monitoring and recording progress on every activity, floor by floor. Some activities are lagging seriously behind because of manpower problems by subtrades - e.g. chimney gyproc - despite continuing excellent weather.

October 20 Schedule - Progress as of October 20

Had hoped to have elevator operational in time for distributing cabinets and appliances to each floor. This won't happen.

Previous field update used to update schedule. New schedule shown in figure 2-42 for critical activities only. Projected completion date is now December 10. Making up for lost time.

REPCON™

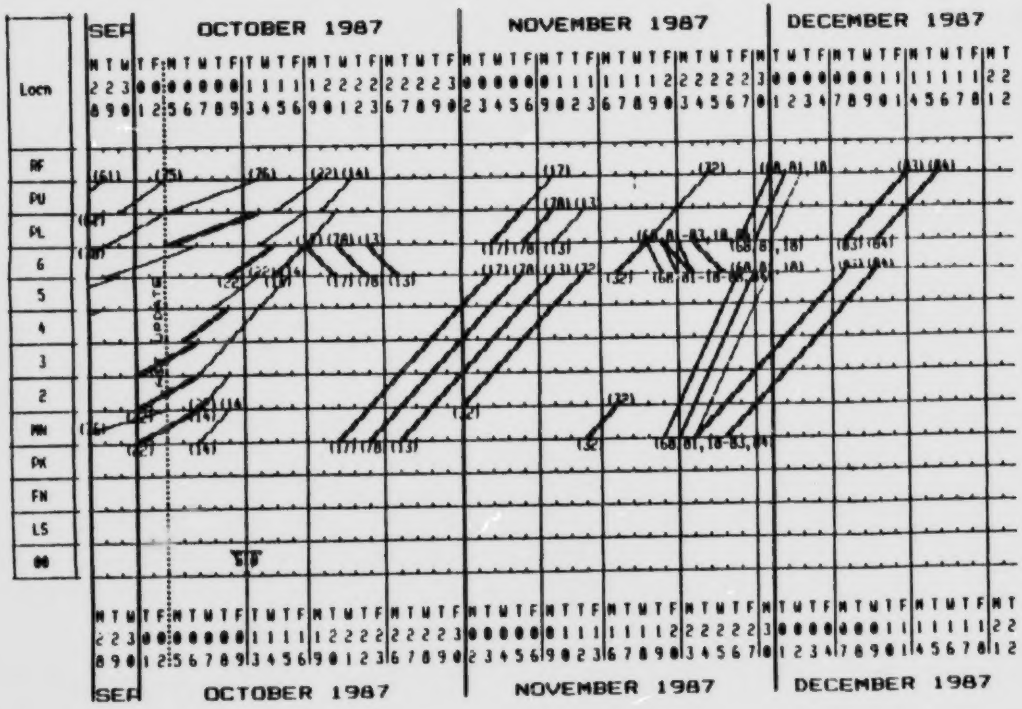
TIFFANY PLACE (43RD & YEW)

LINEAR PLANNING CHART

```
+---------------------------------+
K | *  critical act.                |
E | p  act. has procurement seq.   |
Y | c  completed                    |
+---------------------------------+
```

Report Date : 1987-10-07
Report Time : 06:36:01
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
Progress as of : 1987-10-02
Schedule Window
From 28SEP87 To 22DEC87
From LS To RF

[illegible] LATEST
REVISIONS -
FLOOR 6 NOW
A PROBLEM!
OCT 7/87



ACTIVITY KEY

Act No	Type	Act Description
*(13) 060100	N	KITCHEN CABINETS
*(14) 060200	S	BATHROOM VANITIES
*(17) 100100	N	PAINT UNDER/PRIMER/FINSH COATS
*(18) 100200	N	PAINT TOUCH-UP
*(22) 110400	N	BATHROOM CERAMIC TILE
*(32) 150300	N	PLUMBING FINISHING
*c(61) 710200	P	INSULATION
*(68) 920100	N	CARPETING
*c(75) G17100	N	DRYWALL
*(76) G17200	S	GYPSUM JOINTS
*(78) G17400	N	HARDWOOD FLOORING
*(81) G18200	P	FINSH CARPENTRY III:DOORS
*(83) G19000	N	CLEAN APARTMENTS
*(84) G19100	N	APARTMENT DEFICIENCIES
*(118) G80300		ELEVATOR CAB ONSITE

Figure 2-39 October 2, 1987 Schedule Update - Critical Activities Only.

TIFFANY PLACE (43RD & YEW)

LINEAR PLANNING CHART

```
+-------------------------------+
K | *  critical act.            |
E | p  act. has procurement seq.|
Y | c  completed                |
+-------------------------------+
```

```
Report Date      : 1987-10-07
Report Time      : 06:40:57
File Used        : C:\REPCONC\TIF\TIF
Revision Number  : 1
Progress as of   : 1987-10-02
Schedule Window
  From 28SEP87  To 22DEC87
  From LS To RF
```

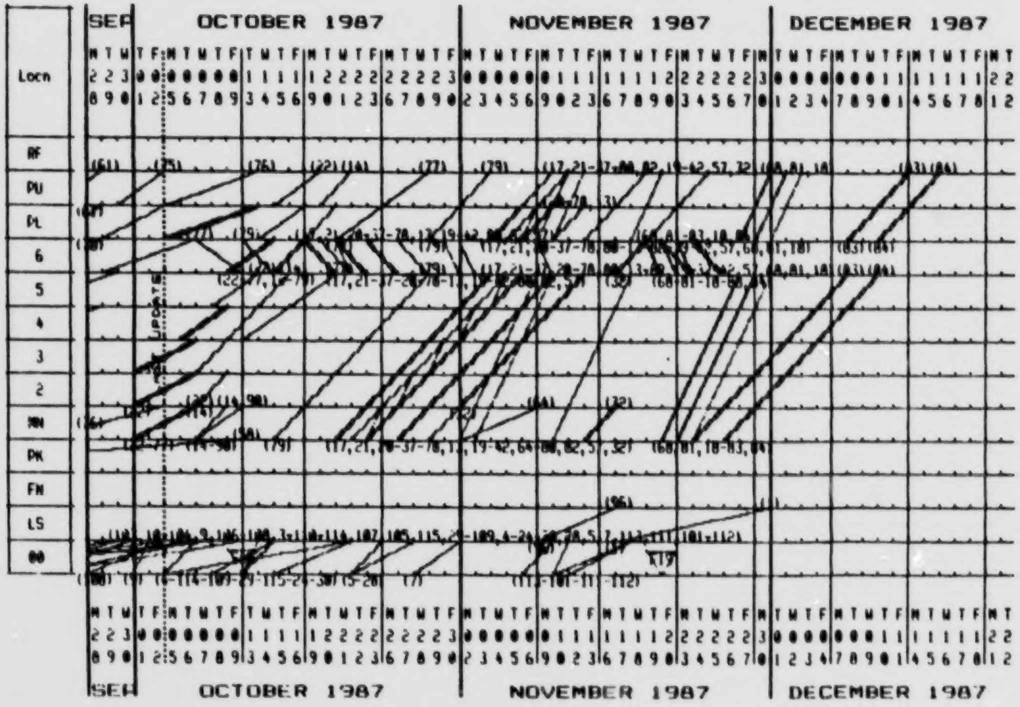


Figure 2-40 October 2, 1987 Schedule Update - All Activities.

```
ACTIVITY KEY
     Act No Type Act Description
  ( 1) 0121LS      LANDSCAPING
  ( 3) 022200      APPLY PAPER & MESH
  ( 4) 022300      APPLY ACRYLIC FINSH
  ( 5) 022400      CAULK WINDOWS
  ( 7) 023700      REMOVE SCAFFOLDING
 c( 9) 042200      CONNECT PERMANENT POWER
 c(10) 052100      TELEPHONE MANHOLES
 *(13) 060100  N   KITCHEN CABINETS
 *(14) 060200  S   BATHROOM VANITIES
 *(17) 100100  N   PAINT UNDER/PRIMER/FINSH
 *(18) 100200  N   PAINT TOUCH-UP
  (19) 110100  N   KITCHEN CERAMIC TILES
  (20) 110200  N   INSTALL MARBLE ENTRANCES
  (21) 110300  N   INSTALL TILE BALCONIES
 *(22) 110400  N   BATHROOM CERAMIC TILE
  (24) 122200      ELEVATOR CONTROLS
  (28) 122600      TEST ELEVATOR SYSTEM
  (29) 122700      INSTALL ELEVATOR CAR
  (30) 122800      ADJUST ELEVATOR DOORS
 *(32) 150300  N   PLUMBING FINISHING
  (37) 151800  S   FIRE CABINET HOSES/COVER.
  (42) 160300  N   ELECTRICAL FINISHING/FIXTU
  (57) 510500  N   VENTILATION FINISHING
  (58) 513MRM      MECHANICAL ROOM
*c(61) 710200  P   INSULATION
  (64) 737300      WATERPROOFING EXT. MAIN
 *(68) 920100  N   CARPETING
*c(75) GL7100  N   DRYWALL
 *(76) G17200  S   GYPSUM JOINTS
  (77) G17300  N   PLASTER CEILING
 *(78) G17400  N   HARDWOOD FLOORING
  (79) G1A000  N   FINSH CARPENTRY I:TRIMS
  (80) G1A100  N   FINSH CARPENTRY II: [illegible]
 *(81) G1A200      FINSH CARPENTRY III:[illegible]
  (82) G1A300  N   [illegible]
 *(83) G1[illegible]  N   CLEAN [illegible]
 *(84) G1[illegible]      [illegible]
  (90) [illegible]      [illegible]
  ([illegible]) [illegible]      [illegible]
  (101) G3[illegible]      INSTALL [illegible]
 c(103) G3[illegible]      ELEVATOR [illegible]
 c(104) G3A100      ELEVATOR [illegible]
```

```
 c(106) G3A300      CHIMNEY FRAMING
  (107) G3A400      CHIMNEY [illegible]
 c(108) G3A500      CHIMNEY DUCTWORK
  (109) G3A600      CHIMNEY STUCCO
  (110) G3A700      METAL HANDRAILS-STAIRWELL
  (111) G3A800      INSTALL KITCHEN APPLIANCES
  (112) G3A900      FINISH HARDWOOD FLOORS
  (113) G3[illegible]      INSTALL VIDEO SYSTEM
  (114) G37100      REMOVE TEMPORARY [illegible]
  (115) G3[illegible]      CONNECT GAS METER
 *(118) G80300      ELEVATOR CAB [illegible]
  (119) G80400      SHELL OCCUPANCY PERMIT
```

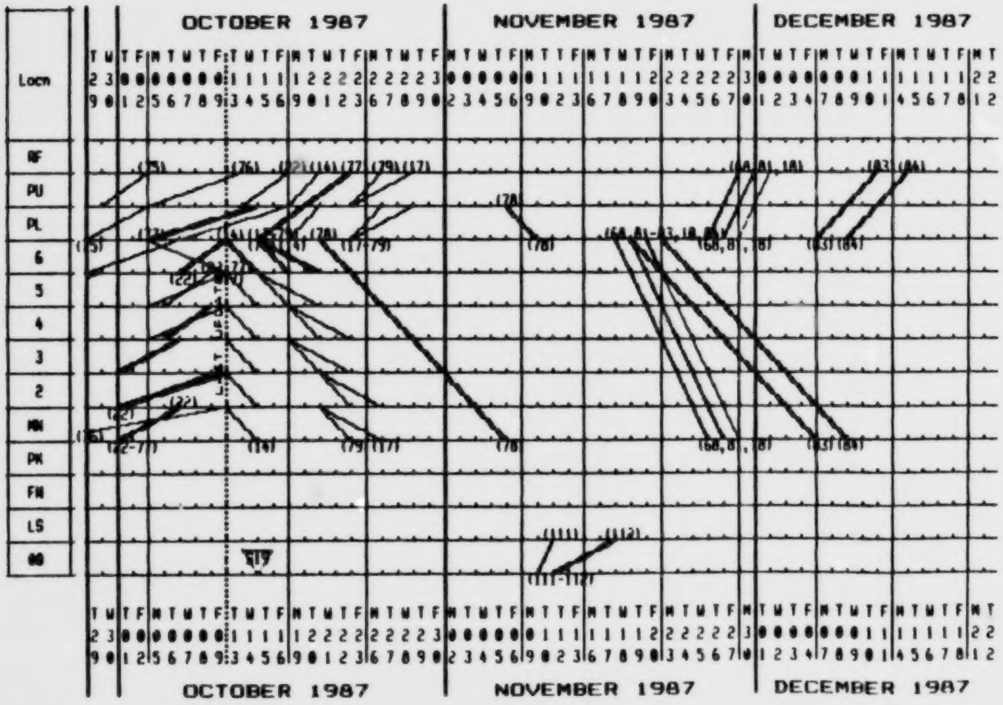
REPCON™

TIFFANY PLACE (43RD & YEW)

LINEAR PLANNING CHART

```
+-------------------------------+
K | *   critical act.           |
E | p   act. has procurement seq. |
Y | c   completed               |
+-------------------------------+
```

Report Date : 1987-10-11
Report Time : 21:06:15
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
Progress as of : 1987-10-09
Schedule Window
From 29SEP87 To 22DEC87
From LS To RF



ACTIVITY KEY

	Act No	Type	Act Description
*(14)	060200	S	BATHROOM VANITIES
*(17)	100100	S	PAINT UNDER/PRIMER/FINSH COATS
*(18)	100200	N	PAINT TOUCH-UP
*(22)	110400	N	BATHROOM CERAMIC TILE
*(68)	920100	N	CARPETING
*c(75)	617100	N	DRYWALL
*(76)	617200	S	GYPSUM JOINTS
*(77)	617300	N	PLASTER CEILING
*(78)	617400	N	HARDWOOD FLOORING
*(79)	618000	N	FINSH CARPENTRY I:TRIMS/CASING
*(81)	618200	P	FINSH CARPENTRY III:DOORS
*(83)	619000	N	CLEAN APARTMENTS
*(84)	619100	N	APARTMENT DEFICIENCIES
*(111)	638000		INSTALL KITCHEN APPLIANCES
*(112)	638900		FINISH HARDWOOD FLOORS
*(119)	600300		ELEVATOR CAB ONSITE

Figure 2-41 October 9, 1987 Schedule Update.

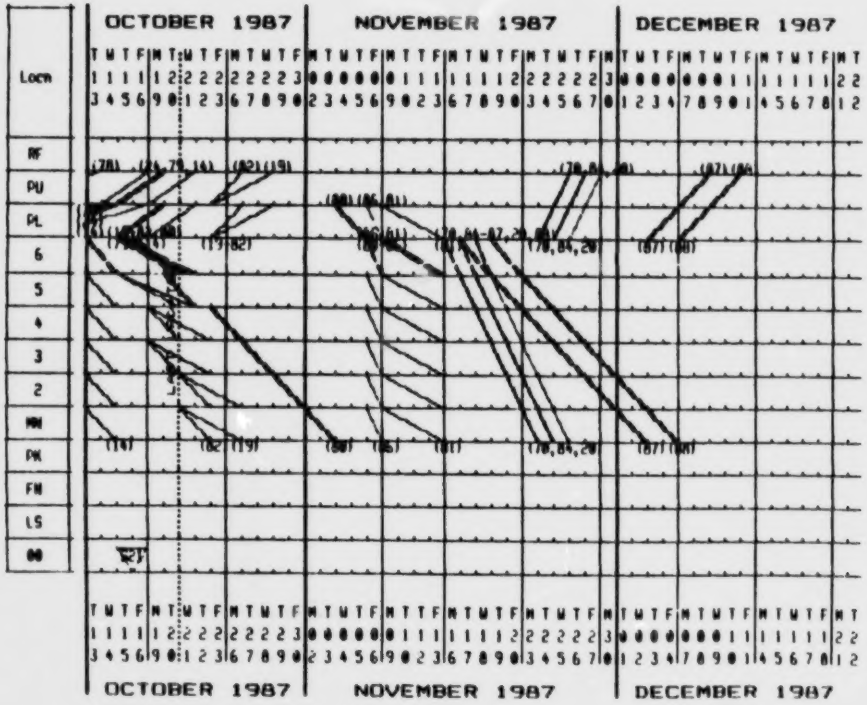
REPCON™

TIFFANY PLACE (43RD & YEW)

LINEAR PLANNING CHART

```
+------------------------------+
K | *  critical act.           |
E | p  act. has procurement seq. |
Y | c  completed               |
+------------------------------+
```

Report Date : 1987-10-20
Report Time : 15:55:56
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
Progress as of : 1987-10-20
Schedule Window
From 13OCT87 To 22DEC87
From LS To RF



ACTIVITY KEY

	Act No	Type	Act Description
*(14)	060200	S	BATHROOM VANITIES
*(19)	100100	S	PAINT UNDER/PRIMER/FINSH COATS
*(20)	100200	N	PAINT TOUCH-UP
*c(24)	110400	N	BATHROOM CERAMIC TILE
*(70)	920100	N	CARPETING
*c(78)	617200	S	GYPSUM JOINTS
*c(79)	617300	N	PLASTER CEILING
*(80)	617400	N	HARDWOOD FLOORING
*(81)	617500	S	FINISH HARDWOOD FLOORS
*(82)	610000	N	FINSH CARPENTRY I:TRIMS/CASING
*(84)	618200	P	FINSH CARPENTRY III:DOORS
*(86)	618400	S	INSTALL KITCHEN APPL/HW TANK
*(87)	619000	N	CLEAN APARTMENTS
*(88)	619100	N	APARTMENT DEFICIENCIES
*c(121)	600300		ELEVATOR CAB ONSITE

Figure 2-42 October 20, 1987 Schedule Update.

New field update report issued (figure 2-43). A new feature is a manpower reporting format at the end. Decision taken to monitor subtrade manpower usage more closely.

Further subdivision of subtrade work continues - now using a two pass operation for plumbing - bathrooms, then kitchens. Electrical finishing is being done in several passes.

Visited site on October 26. Scaffolding still not removed. Can't start waterproofing at MN level.

November 1, 1987 Schedule - Progress as of October 30

Based on previous field update report, schedule was updated. Completion date now projected to be December 14, 1987 - see figure 2-44.

A new field update report was issued.

Near the end of November, a meeting was held with RS. He had continued recording progress and using the field update report for managing the job. His feeling at that time was that the schedule was sufficiently accurate that continued updating was not required as completion was in sight.

RS provided additional suggestions as to what activities he would add in the future for the next job. They included closet shelving, spray insulation in parkade, sidewalk crossing (involves permits, approvals - get them going a month before occupancy permit), painting of stairwells and perimeter backfill - requires a certificate of inspection that must be filed with city hall. Not having it can hold up sidewalk crossings.

The 6th floor purchaser moved in late November. Work continued until mid December. Miscellaneous outside work (landscaping, tiling, awning) continued sporadically into the beginning of February 1988.

2.5 SUMMARY OF FINDINGS FROM CASE STUDIES

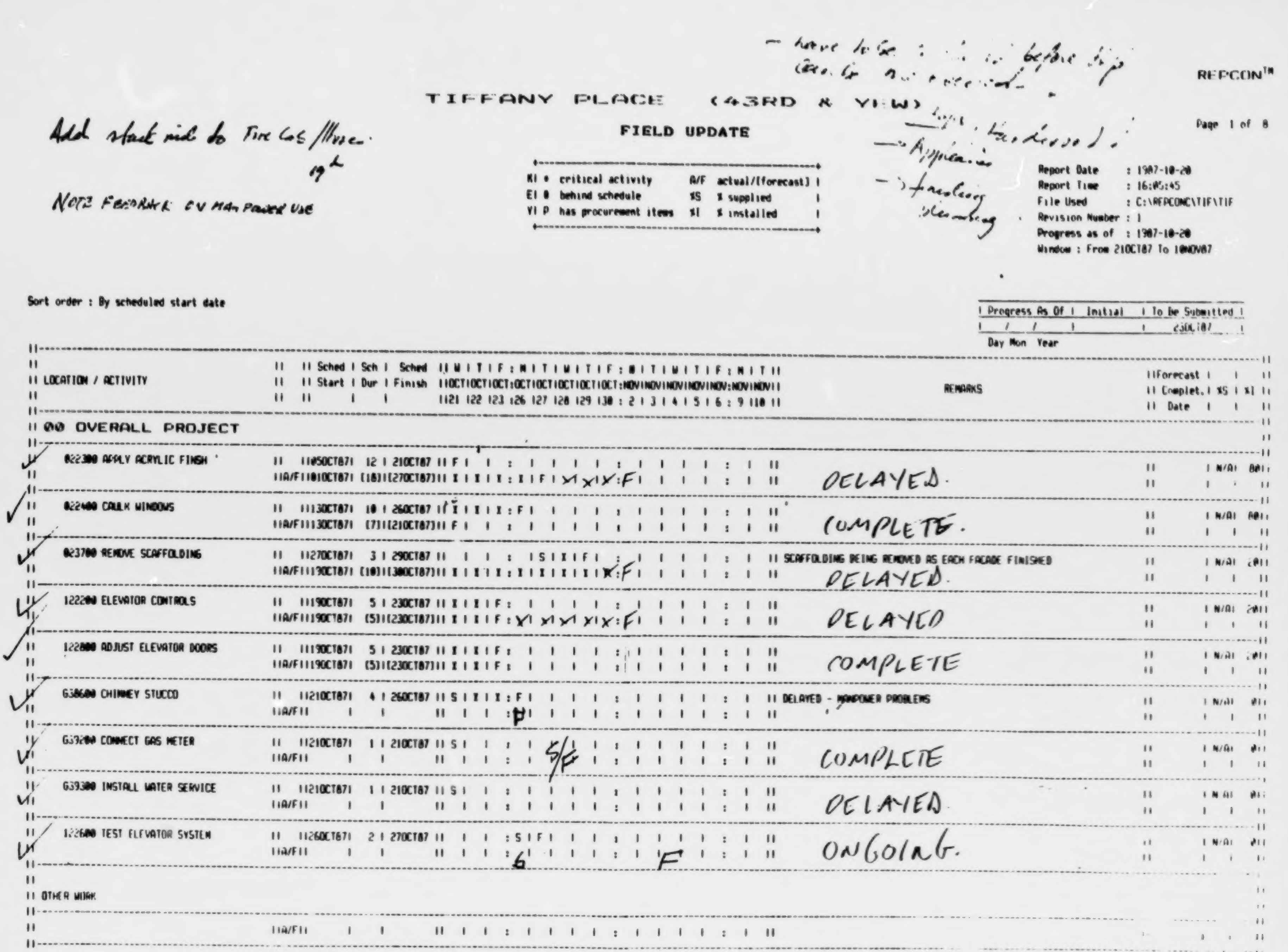
An overview of current practices, derived in part from the case studies, was presented in Chapter 1 and is not restated here. In this section we direct our attention to specific issues, several of which are addressed in detail in Chapters 4 and 5.

1. The current scoping of a project in terms of activities is poorly performed for purposes of effective site management. Because of the extensive use of subcontracting, knowledge of the activities required for the various systems which comprise a building has been lost by the general contractor. Also, duration estimation is not done well.

2. Regulatory and utility processes are not well understood. The permit process is seldom included in the schedule and its neglect can cost unnecessary delays. For utilities, water, sewage, gas, phone, video, and permanent power should be tracked.

3. Site finishing (hard and soft landscaping), roofing and substructure work is often neglected in terms of meaningful definition in the schedule.

4. Subtrade work is not well defined in the subcontracts. Considerable benefits could accrue from standardizing activity breakdowns and appending them to each contract. As part of the contract, subtrades would be required to give activity durations, manpower requirements, and price breakdowns corresponding to the activity breakdown. Much of this process could be automated.



Add stack mil to Fire Cos/Misc. 19th

NOTE FEEDBACK ON MANPOWER USE

— have to [illegible] before [illegible]
[illegible]
[illegible]
—> Appearance
—> finishing
cleaning

```
                                                                                                              REPCON(TM)
                              TIFFANY PLACE   (43RD & YEW)
                                                                                                          Page  1 of  8
                                     FIELD UPDATE
                        +--------------------------------------------+
                        KI * critical activity     A/F actual/[forecast] |      Report Date      : 1987-10-20
                        EI @ behind schedule       %S  % supplied        |      Report Time      : 16:05:45
                        YI P has procurement items %I  % installed       |      File Used        : C:\REPCONC\TIF\TIF
                        +--------------------------------------------+      Revision Number  : 1
                                                                            Progress as of   : 1987-10-20
                                                                            Window : From 21OCT87 To 10NOV87

Sort order : By scheduled start date
                                                                           | Progress As Of |  Initial   | To be Submitted |
                                                                           |  /   /         |            |     23OCT87     |
                                                                            Day Mon  Year
||-------------------------------------------------------------------------------------------------------------------------||
||                         ||   || Sched | Sch |  Sched  ||M|T|F:M|T|W|T|F:M|T|W|T|F:M|T||                  ||Forecast |    |   ||
|| LOCATION / ACTIVITY     ||   || Start | Dur | Finish  ||OCT|OCT|OCT:OCT|OCT|OCT|OCT|OCT:NOV|NOV|NOV|NOV|NOV:NOV|NOV||  REMARKS  || Complet.| %S | %I||
||                         ||   ||       |     |         ||21 |22 |23 :26 |27 |28 |29 |30 : 2 | 3 | 4 | 5 | 6 : 9 |10 ||         || Date    |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
|| 00 OVERALL PROJECT
||-------------------------------------------------------------------------------------------------------------------------||
    022300 APPLY ACRYLIC FINSH   ||    ||05OCT87|  12 | 21OCT87 || F |  |  :  |  |  |  |  :  |  |  |  |  :  | ||                    ||  | N/A| 00||
||                              ||A/F||01OCT87| [18]|[27OCT87]|| X | X| X: X| F| X| X| X: F|  |  |  |  :  | ||  DELAYED.          ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
||  022400 CAULK WINDOWS         ||    ||13OCT87|  10 | 26OCT87 || X | X| X: F|  |  |  |  :  |  |  |  |  :  | ||                    ||  | N/A| 00||
||                              ||A/F||13OCT87|  [7]|[21OCT87]|| F |  |  :  |  |  |  |  :  |  |  |  |  :  | ||  COMPLETE.         ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
    023700 REMOVE SCAFFOLDING    ||    ||27OCT87|   3 | 29OCT87 ||   |  |  :  | S| X| F|  :  |  |  |  |  :  | || SCAFFOLDING BEING REMOVED AS EACH FACADE FINISHED ||  | N/A| 20||
||                              ||A/F||13OCT87| [10]|[30OCT87]|| X | X| X: X| X| X| X| X: F|  |  |  |  :  | ||  DELAYED.          ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
||  122200 ELEVATOR CONTROLS     ||    ||19OCT87|   5 | 23OCT87 || X | X| F:  |  |  |  |  :  |  |  |  |  :  | ||                    ||  | N/A| 20||
||                              ||A/F||19OCT87|  [5]|[23OCT87]|| X | X| F: X| X| X| X| X: F|  |  |  |  :  | ||  DELAYED           ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
||  122800 ADJUST ELEVATOR DOORS ||    ||19OCT87|   5 | 23OCT87 || X | X| F:  |  |  |  |  :  |  |  |  |  :  | ||                    ||  | N/A| 20||
||                              ||A/F||19OCT87|  [5]|[23OCT87]|| X | X| F:  |  |  |  |  :  |  |  |  |  :  | ||  COMPLETE          ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
    G38600 CHIMNEY STUCCO        ||    ||21OCT87|   4 | 26OCT87 || S | X| X: F|  |  |  |  :  |  |  |  |  :  | || DELAYED - MANPOWER PROBLEMS ||  | N/A|  0||
||                              ||A/F||       |     |         ||   |  |  : F|  |  |  |  :  |  |  |  |  :  | ||                    ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
||  G33200 CONNECT GAS METER     ||    ||21OCT87|   1 | 21OCT87 || S |  |  :  |S/F| |  |  :  |  |  |  |  :  | ||                    ||  | N/A|  0||
||                              ||A/F||       |     |         ||   |  |  :  |  |  |  |  :  |  |  |  |  :  | ||  COMPLETE          ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
||  G39300 INSTALL WATER SERVICE ||    ||21OCT87|   1 | 21OCT87 || S |  |  :  |  |  |  |  :  |  |  |  |  :  | ||                    ||  | N/A|  0||
||                              ||A/F||       |     |         ||   |  |  :  |  |  |  |  :  |  |  |  |  :  | ||  DELAYED.          ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
||  122600 TEST ELEVATOR SYSTEM  ||    ||26OCT87|   2 | 27OCT87 ||   |  |  : S| F|  |  |  :  |  |  |  |  :  | ||                    ||  | N/A|  0||
||                              ||A/F||       |     |         ||   |  |  : S|  |  |  |  :  |  | F|  |  :  | ||  ONGOING.          ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
||
|| OTHER WORK
||-------------------------------------------------------------------------------------------------------------------------||
||                              ||A/F||       |     |         ||   |  |  :  |  |  |  |  :  |  |  |  |  :  | ||                    ||  |    |   ||
||-------------------------------------------------------------------------------------------------------------------------||
```

Figure 2-43   Field Update Report with Subtrade Manpower Monitoring.

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	W OCT 21	T OCT 22	F OCT 23	M OCT 26	T OCT 27	W OCT 28	T OCT 29	F OCT 30	M NOV 2	T NOV 3	W NOV 4	T NOV 5	F NOV 6	M NOV 9	T NOV 10	REMARKS	Forecast Complet. Date	%S	%I
G37600 INSTALL VACUUM UNITS/TEST		23OCT87	5	04NOV87							S	X	X	X	F							N/A	0
	A/F												S	X	F					DELAYED.			
G39000 INSTALL VIDEO SYSTEM		29OCT87	2	30OCT87							S	F										N/A	0
	A/F														S	F				DELAYED. DEPENDANT ON PAINTING COMP.			
LS LANDSCAPING																							
G260LS DRIVEWAY		09NOV87	5	16NOV87														S	X			N/A	0
	A/F																			OK.			
PK PARKING																							
5130PK MECHANICAL ROOM		09SEP87	40	04NOV87	X	X	X	X	X	X	X	X	X	X	F					ALL WORK COMPLETE EXCEPT FOR WATER METER		N/A	50
	A/F	31AUG87	(38)	(23OCT87)	X	X	F																
MN GROUND FLOOR																							
0604MN BATHROOM CABINET TOPS		21OCT87	2	22OCT87	S	F																N/A	0
	A/F																			COMPLETE			
1001MN PAINT UNDER/PRIMER/FINSH COATS		21OCT87	4	26OCT87	S	X	X	F														N/A	0
	A/F				S							S	X	X	F								
G100MN FINSH CARPENTRY I:TRIMS/CASING		21OCT87	2	22OCT87	S	F																N/A	0
	A/F											S	F							DELAYED			
1510MN FIRE CABINET HOSES/COVERS		27OCT87	1	27OCT87					S													N/A	0
	A/F																			DELAY TO 2ND WK. OF NOV.			
7373MN WATERPROOFING EXT. MAIN SLAB		02NOV87	5	06NOV87									S	X	X	X	F					N/A	0
	A/F																			OK.			
G174MN HARDWOOD FLOORING		02NOV87	2	03NOV87									S	F								N/A	0
	A/F										S	F								ADVANCED. COMPLETE.			
1102MN INSTALL MARBLE ENTRANCES		04NOV87	2	05NOV87											S	F						N/A	0
	A/F					S	F													ADVANCED. COMPLETE.			
0601MN KITCHEN CABINETS		05NOV87	2	06NOV87												S	F					N/A	0
	A/F													S	F					ADVANCED			
G101MN FINSH CARPENTRY II: TRACKS/HRD		05NOV87	2	06NOV87												S	F					N/A	0
	A/F																			OK.			
OTHER WORK																							
	A/F																						
	A/F																						
	A/F																						

Figure 2-43 (cont'd)

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	W OCT 21	T OCT 22	F OCT 23	M OCT 26	T OCT 27	W OCT 28	T OCT 29	F OCT 30	M NOV 2	T NOV 3	W NOV 4	T NOV 5	F NOV 6	M NOV 9	T NOV 10	REMARKS	Forecast Complet. Date	%S	%I
G184MN INSTALL KITCHEN APPL/HW TANK		06NOV87	1	06NOV87													S			OK *HWT. INSTALLED.		N/A	0
	A/F																						
0603MN KITCHEN CABINET TOPS		09NOV87	2	10NOV87														S	F	OK		N/A	0
	A/F																						
1103MN INSTALL TILE BALCONIES		09NOV87	2	10NOV87														S	F	OK		N/A	0
	A/F																						
G175MN FINISH HARDWOOD FLOORS		09NOV87	4	13NOV87														S	X	OK.		N/A	0
	A/F																						
2 2ND FLOOR																							
110202 INSTALL MARBLE ENTRANCES		27OCT87	2	28OCT87					S	F										WORK STARTED BEFORE PAINTING FINISHED - LOGIC BROKEN		N/A	50
	A/F	20OCT87	[2]	[21OCT87]	F															SEQUENCE CHANGED FOR 28OCT87 UPDATE 2 TO FL,MN			
060402 BATHROOM CABINET TOPS		21OCT87	2	22OCT87	S	F														COMPLETE		N/A	0
	A/F																						
100102 PAINT UNDER/PRIMER/FINSH COATS		21OCT87	4	26OCT87	S	X	X	F												DELAYED. ONGOING.		N/A	0
	A/F				S							S	X	X	F								
G18002 FINSH CARPENTRY I:TRIMS/CASING		21OCT87	2	22OCT87	S	F														DELAYED.		N/A	0
	A/F								S	F													
151002 FIRE CABINET HOSES/COVERS		27OCT87	1	27OCT87					S													N/A	0
	A/F																			DELAY TO 2ND WK. OF NOV.			
G17402 HARDWOOD FLOORING		29OCT87	2	30OCT87							S	F								COMPLETE		N/A	0
	A/F									S	F												
060102 KITCHEN CABINETS		03NOV87	2	04NOV87										S	F					OK.		N/A	0
	A/F																						
G18102 FINSH CARPENTRY II: TRACKS/HRD		03NOV87	2	04NOV87										S	F					OK.		N/A	0
	A/F																						
060302 KITCHEN CABINET TOPS		05NOV87	2	06NOV87												S	F			OK.		N/A	0
	A/F																						
110302 INSTALL TILE BALCONIES		05NOV87	2	06NOV87												S	F			OK. Plumb		N/A	0
	A/F																						
G18402 INSTALL KITCHEN APPL/HW TANK		06NOV87	1	06NOV87													S			OK. * HWT. INSTALLED.		N/A	0
	A/F																						
OTHER WORK																							
	A/F																						
	A/F																						
	A/F																						

Figure 2-43 (cont'd)

```
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||                                          ||    || Sched  | Sch |  Sched   || W | T | F : M | T | W | T | F : M | T | W | T | F : M | T ||                                                  ||Forecast |     |    ||
|| LOCATION / ACTIVITY                      ||    || Start  | Dur | Finish   ||OCT|OCT|OCT:OCT|OCT|OCT|OCT|OCT:NOV|NOV|NOV|NOV|NOV:NOV|NOV||                     REMARKS                      || Complet.| %S  | %I ||
||                                          ||    ||        |     |          ||21 |22 |23 :26 |27 |28 |29 |30 : 2 | 3 | 4 | 5 | 6 : 9 |10 ||                                                  ||  Date   |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    110102 KITCHEN CERAMIC TILES          ||    ||09NOV87 |  2  | 10NOV87  ||   |   |   :   |   |   |   |   :   |   |   |   |   : S | F ||                                                  ||         | N/A |  0 ||
||                                          ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK                                              ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 617502 FINISH HARDWOOD FLOORS         ||    ||09NOV87 |  4  | 13NOV87  ||   |   |   :   |   |   |   |   :   |   |   |   |   : S | I ||                                                  ||         | N/A |  0 ||
|| V                                        ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                             ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  3 3RD FLOOR                                                                                                                                               ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 100103 PAINT UNDER/PRIMER/FINSH COATS ||    ||19OCT87 |  4  | 22OCT87  || X | F |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                                  ||         | N/A | 40 ||
|| V                                        ||A/F ||19OCT87 | (4) |(22OCT87) || X | F <----------------- S : x | x | F |   |   :   |   ||  DELAYED.                                        ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 110203 INSTALL MARBLE ENTRANCES       ||    ||29OCT87 |  2  | 30OCT87  ||   |   |   :   |   |   | S | F :   |   |   |   |   :   |   || WORK STARTED BEFORE PAINTING FINISHED - LOGIC BROKEN ||   | N/A | 30 ||
|| W                                        ||A/F ||20OCT87 | (2) |(21OCT87) || F |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                             ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 060403 BATHROOM CABINET TOPS          ||    ||21OCT87 |  2  | 22OCT87  || S | F |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                                  ||         | N/A |  0 ||
|| V                                        ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  COMPLETE                                        ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 151003 FIRE CABINET HOSES/COVERS      ||    ||23OCT87 |  1  | 23OCT87  ||   |   | S :   |   |   |   |   :   |   |   |   |   :   |   ||                                                  ||         | N/A |  0 ||
||                                          ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  DELAY TO 2ND WK. OF NOV.                        ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    617403 HARDWOOD FLOORING              ||    ||27OCT87 |  2  | 28OCT87  ||   |   |   :   | S | F |   |   :   |   |   |   |   :   |   ||                                                  ||         | N/A |  0 ||
|| /                                        ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  COMPLETE.                                       ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 060103 KITCHEN CABINETS               ||    ||30OCT87 |  2  | 02NOV87  ||   |   |   :   |   |   |   | S : F |   |   |   |   :   |   ||                                                  ||         | N/A |  0 ||
|| V                                        ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                             ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    610103 FINSH CARPENTRY II: TRACKS/HRD ||    ||30OCT87 |  2  | 02NOV87  ||   |   |   :   |   |   |   | S : F |   |   |   |   :   |   ||                                                  ||         | N/A |  0 ||
||                                          ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   | S | F :   |   ||  DELAYED.                                        ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 060303 KITCHEN CABINET TOPS           ||    ||03NOV87 |  2  | 04NOV87  ||   |   |   :   |   |   |   |   :   | S | F |   |   :   |   ||                                                  ||         | N/A |  0 ||
|| V                                        ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   : S | F ||  DELAYED.                                        ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    110303 INSTALL TILE BALCONIES         ||    ||03NOV87 |  2  | 04NOV87  ||   |   |   :   |   |   |   |   :   | S | F |   |   :   |   ||                                                  ||         | N/A |  0 ||
|| /                                        ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                             ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    110103 KITCHEN CERAMIC TILES          ||    ||05NOV87 |  2  | 06NOV87  ||   |   |   :   |   |   |   |   :   |   |   | S | F :   |   ||                                                  ||         | N/A |  0 ||
||                                          ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |S/F||  DELAYED.                                        ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 610403 INSTALL KITCHEN APPL/HW TANK   ||    ||06NOV87 |  1  | 06NOV87  ||   |   |   :   |   |   |   |   :   |   |   |   | S :   |   ||                                                  ||         | N/A |  0 ||
|| W                                        ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |S/F||  DELAYED.   * HWT. INSTALLED.                    ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  / 617503 FINISH HARDWOOD FLOORS         ||    ||09NOV87 |  4  | 13NOV87  ||   |   |   :   |   |   |   |   :   |   |   |   |   : S | I ||                                                  ||         | N/A |  0 ||
|| V                                        ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK                                              ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||                                                                                                                                                            ||
|| OTHER WORK                                                                                                                                                 ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||                                          ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                                  ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||                                          ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                                  ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
||                                          ||A/F ||        |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                                  ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------||
```

Figure 2-43 (cont'd)

```
||
|| LOCATION / ACTIVITY                     ||    || Sched | Sch |  Sched   ||M|T|T|F:M|T|W|T|F:M|T|W|T|F:M|T||                                                  ||Forecast |     |    ||
||                                         ||    || Start | Dur | Finish   ||OCT|OCT|OCT:OCT|OCT|OCT|OCT|OCT:NOV|NOV|NOV|NOV|NOV:NOV|NOV||      REMARKS                            || Complet.| %S  | %I ||
||                                         ||    ||       |     |          ||21 |22 |23 :26 |27 |28 |29 |30 : 2 | 3 | 4 | 5 | 6 : 9 |10 ||                                         ||  Date   |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  4/4TH FLOOR
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    100104 PAINT UNDER/PRIMER/FINSH COATS ||    ||19OCT87|   4 | 22OCT87  || X | F |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                         ||         | N/A | 40 ||
||                                         ||A/F||19OCT87|  [4]|[22OCT87] || X | F |   :   |   | SXX:F |   :   |   |   |   |   :   |   ||  DELAYED.                               ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    060404 BATHROOM CABINET TOPS          ||    ||21OCT87|   2 | 22OCT87  || S | F |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  COMPLETE                               ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    110204 INSTALL MARBLE ENTRANCES       ||    ||23OCT87|   2 | 26OCT87  ||   |   | S : F |   |   |   |   :   |   |   |   |   :   |   || SEQUENCE CHANGED AS OF 20OCT87 UPDATE - 2 TO PL,MN ||    | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  COMPLETE.                              ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    151004 FIRE CABINET HOSES/COVERS      ||    ||23OCT87|   1 | 23OCT87  ||   |   | S :   |   |   |   |   :   |   |   |   |   :   |   ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  DELAY TO 2ND WK. OF NOV.               ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    G17404 HARDWOOD FLOORING              ||    ||23OCT87|   2 | 26OCT87  ||   |   | S : F |   |   |   |   :   |   |   |   |   :   |   ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  COMPLETE                               ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    060104 KITCHEN CABINETS               ||    ||28OCT87|   2 | 29OCT87  ||   |   |   :   |   | S | F |   :   |   |   |   |   :   |   ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   : S F |   |   |   :   |   |   |   |   :   |   ||  COMPLETE                               ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    G18104 FINSH CARPENTRY II: TRACKS/HRD ||    ||28OCT87|   2 | 29OCT87  ||   |   |   :   |   | S | F |   :   |   |   |   |   :   |   ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   | S F   |   |   :   |   ||  DELAYED                                ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    060304 KITCHEN CABINET TOPS           ||    ||30OCT87|   2 | 02NOV87  ||   |   |   :   |   |   |   | S : F |   |   |   |   :   |   ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                    ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    110304 INSTALL TILE BALCONIES         ||    ||30OCT87|   2 | 02NOV87  ||   |   |   :   |   |   |   | S : F |   |   |   |   :   |   ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                    ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    110104 KITCHEN CERAMIC TILES          ||    ||03NOV87|   2 | 04NOV87  ||   |   |   :   |   |   |   |   :   | S | F |   |   :   |   ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                    ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    G18404 INSTALL KITCHEN APPL/HW TANK   ||    ||06NOV87|   1 | 06NOV87  ||   |   |   :   |   |   |   |   :   |   |   |   | S :   |   ||                      *HWT. INSTALLED.   ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                    ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    G17504 FINISH HARDWOOD FLOORS         ||    ||09NOV87|   4 | 13NOV87  ||   |   |   :   |   |   |   |   :   |   |   |   |   : S | X ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                    ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    G18304 BALCONY HANDRAILS & GLAZING    ||    ||10NOV87|   1 | 10NOV87  ||   |   |   :   |   |   |   |   :   |   |   |   |   :   | S ||                                         ||         | N/A |  0 ||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||  OK.                                    ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||  5 5TH FLOOR
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||    100105 PAINT UNDER/PRIMER/FINSH COATS ||    ||15OCT87|   4 | 20OCT87  ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   || CAN'T COMPLETE UNTIL BASEBOARDS INSTALLED ||       | N/A | 40 ||
||                                         ||A/F||15OCT87|  [5]|[21OCT87] || F |   |   :   |   |   |   |   : / |   |   |   |   :   |   ||                                         ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||
|| OTHER WORK
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                         ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                         ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
||                                         ||A/F||       |     |          ||   |   |   :   |   |   |   |   :   |   |   |   |   :   |   ||                                         ||         |     |    ||
||------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------||
```

Figure 2-43 (cont'd)

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	W OCT 21	T OCT 22	F OCT 23	M OCT 26	T OCT 27	W OCT 28	T OCT 29	F OCT 30	M NOV 2	T NOV 3	W NOV 4	T NOV 5	F NOV 6	M NOV 9	T NOV 10	REMARKS	Forecast Complet. Date	%S	%I
G17405 HARDWOOD FLOORING		23OCT87	2	26OCT87			S	F												SLEEPERS DOWN AS OF 20OCT87		N/A	10
	A/F	20OCT87	[2]	[21OCT87]	F															COMPLETE			
060405 BATHROOM CABINET TOPS		21OCT87	2	22OCT87	S	F																N/A	0
	A/F																			COMPLETE.			
151005 FIRE CABINET HOSES/COVERS		22OCT87	1	22OCT87		S																N/A	0
	A/F																			DELAY TO 2ND WK. OF NOV.			
060105 KITCHEN CABINETS		26OCT87	2	27OCT87				S	F													N/A	0
	A/F																			COMPLETE			
G18105 FINSH CARPENTRY II: TRACKS/HRD		26OCT87	2	27OCT87				S	F													N/A	0
	A/F														S	F				DELAYED. (Delayed because have to have paint & hardwood floor finishing complete.			
110205 INSTALL MARBLE ENTRANCES		27OCT87	2	28OCT87					S	F												N/A	0
	A/F																			COMPLETE.			
060305 KITCHEN CABINET TOPS		28OCT87	2	29OCT87						S	F											N/A	0
	A/F											S	F							DELAYED (Supply problem)			
110305 INSTALL TILE BALCONIES		28OCT87	2	29OCT87						S	F											N/A	0
	A/F											S	F							DELAYED.			
110105 KITCHEN CERAMIC TILES		30OCT87	2	02NOV87								S	F									N/A	0
	A/F													S	F					DELAYED.			
G18405 INSTALL KITCHEN APPL/HW TANK		06NOV87	1	06NOV87													S					N/A	0
	A/F																			OK. HWT. INSTALLED.			
G17505 FINISH HARDWOOD FLOORS		09NOV87	4	13NOV87														S	X			N/A	0
	A/F																			OK.			
G18305 BALCONY HANDRAILS & GLAZING		09NOV87	1	09NOV87														S				N/A	0
	A/F																			OK.			
150305 PLUMBING FINISHING		10NOV87	1	10NOV87															S			N/A	0
	A/F										S									ONGOING. (2 person operation near bathrooms/kitchens)			
510505 VENTILATION FINISHING		10NOV87	1	10NOV87															S			N/A	0
	A/F																			OK.			
6 6TH FLOOR																							
100106 PAINT UNDER/PRIMER/FINSH COATS		15OCT87	4	20OCT87																CAN'T COMPLETE UNTIL BASEBOARDS INSTALLED		N/A	40
	A/F	15OCT87	[5]	[21OCT87]	F									F						ONGOING.			
OTHER WORK																							
	A/F																						
	A/F																						
	A/F																						

Figure 2-43 (cont'd)

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	W OCT 21	T OCT 22	F OCT 23	M OCT 26	T OCT 27	W OCT 28	T OCT 29	F OCT 30	M NOV 2	T NOV 3	W NOV 4	T NOV 5	F NOV 6	M NOV 9	T NOV 10	REMARKS	Forecast Complet. Date	%S	%I
060406 BATHROOM CABINET TOPS		21OCT87	2	22OCT87	S	F																N/A	0
	A/F																			COMPLETE.			
060106 KITCHEN CABINETS		22OCT87	2	23OCT87		S	F															N/A	0
	A/F																			COMPLETE.			
151006 FIRE CABINET HOSES/COVERS		22OCT87	1	22OCT87		S																N/A	0
	A/F																			DELAY TO 2nd wk OF nov.			
618106 FINSH CARPENTRY II: TRACKS/HRD		22OCT87	2	23OCT87		S	F													DURATION CHANGED TO 2 DAYS/FLOOR FROM 1 DAY/FLOOR AS PART OF		N/A	0
	A/F													S:F						20OCT87 UPDATE DELAYED.			
060306 KITCHEN CABINET TOPS		26OCT87	2	27OCT87				S	F													N/A	0
	A/F											S:F								DELAYED.			
110306 INSTALL TILE BALCONIES		26OCT87	2	27OCT87				S	F													N/A	0
	A/F										SF									DELAYED.			
110106 KITCHEN CERAMIC TILES		28OCT87	2	29OCT87						S	F											N/A	0
	A/F												SF							DELAYED.			
110206 INSTALL MARBLE ENTRANCES		29OCT87	2	30OCT87							S	F										N/A	0
	A/F						S:F													COMPLETE.			
618306 BALCONY HANDRAILS & GLAZING		06NOV87	1	06NOV87													S					N/A	0
	A/F																			OK.			
618406 INSTALL KITCHEN APPL/HW TANK		06NOV87	1	06NOV87													S					N/A	0
	A/F																			OK. + HWT. INSTALLED kitchen appliances after counter top			
150306 PLUMBING FINISHING		09NOV87	1	09NOV87														S		DURATION REDUCED TO 1 DAY/FLOOR FROM 2 DAYS/FLOOR AS OF 20OCT87		N/A	0
	A/F									S										UPDATE ONGOING			
510506 VENTILATION FINISHING		09NOV87	1	09NOV87														S				N/A	0
	A/F																			OK.			
617506 FINISH HARDWOOD FLOORS		09NOV87	4	13NOV87														S	*			N/A	0
	A/F																			OK.			
160306 ELECTRICAL FINISHING/FIXTURES		10NOV87	1	10NOV87															S	DURATION REDUCED TO 1 DAY/FLOOR FROM 2 DAYS/FLOOR AS OF 20OCT87		N/A	0
	A/F									S										UPDATE (Being broken into several phases)			
PL LOWER PH																							
0602PL BATHROOM VANITIES		17OCT87	2	20OCT87																DOES NOT INCLUDE TOP		N/A	0
	A/F	17OCT87	(3)	(21OCT87)	F															COMPLETE.			
OTHER WORK																							
	A/F																						
	A/F																						
	A/F																						

Figure 2-43 (cont'd)

LOCATION / ACTIVITY		Sched Start	Sch Dur	Sched Finish	W OCT 21	T OCT 22	F OCT 23	M OCT 26	T OCT 27	W OCT 28	T OCT 29	F OCT 30	M NOV 2	T NOV 3	W NOV 4	T NOV 5	F NOV 6	M NOV 9	T NOV 10	REMARKS	Forecast Complet. Date	%S	%I
✓ 0604PL BATHROOM CABINET TOPS		22OCT87	2	23OCT87		S	F													COMPLETE.		N/A	0
	A/F																						
✓ 1001PL PAINT UNDER/PRIMER/FINSH COATS		23OCT87	4	28OCT87			S	X	X	F										DELAYED		N/A	0
	A/F								S						X	X	X	F					
✓ 6100PL FINSH CARPENTRY I:TRIMS/CASING		23OCT87	2	26OCT87			S	F												DELAYED.		N/A	0
	A/F												S	F					[illegible]				
1510PL FIRE CABINET HOSES/COVERS		29OCT87	1	29OCT87							S									DELAY TO 2ND WK. OF NOV.		N/A	0
	A/F																						
✓ 1102PL INSTALL MARBLE ENTRANCES		02NOV87	2	03NOV87									S	F						COMPLETE		N/A	0
	A/F									S	F												
✓ 6174PL HARDWOOD FLOORING		04NOV87	2	05NOV87											S	F				ADVANCED, COMPLETE.		N/A	0
	A/F									S	F												
✓ 6184PL INSTALL KITCHEN APPL/HW TANK		06NOV87	1	06NOV87													S			OUT OF SEQ. COMES AFTER COUNTER TOPS.		N/A	0
	A/F																						
✓ 0601PL KITCHEN CABINETS		09NOV87	2	10NOV87														S	F	ADVANCED.		N/A	0
	A/F												S	F									
6175PL FINISH HARDWOOD FLOORS		09NOV87	4	13NOV87														S	X	OK.		N/A	0
	A/F																						
✓ 6181PL FINSH CARPENTRY II: TRACKS/HRD		09NOV87	2	10NOV87														S	F	OK.		N/A	0
	A/F																						
PU UPPER PH																							
✓ 0602PU BATHROOM VANITIES		19OCT87	2	20OCT87																DOES NOT INCLUDE TOP		N/A	20
	A/F	19OCT87	[3]	[21OCT87]	F															COMPLETE			
✓ 0604PU BATHROOM CABINET TOPS		22OCT87	2	23OCT87		S	F													COMPLETE.		N/A	0
	A/F																						
✓ 1001PU PAINT UNDER/PRIMER/FINSH COATS		23OCT87	4	28OCT87			S	X	X	F										DELAYED.		N/A	0
	A/F								S						X	X	X	F					
✓ 6100PU FINSH CARPENTRY I:TRIMS/CASING		23OCT87	2	26OCT87			S	F												DELAYED.		N/A	0
	A/F												S	F									
1510PU FIRE CABINET HOSES/COVERS		23OCT87	1	29OCT87							S									DELAY TO 2ND WK. OF NOV.		N/A	0
	A/F																						
OTHER WORK																							
	A/F																						
	A/F																						
	A/F																						

Figure 2-43 (cont'd)

TIFFANY PLACE (43RD & YEW)

FIELD UPDATE : MANPOWER USAGE

Page 1 of 1

Report Date : 1987-10-20
Report Time : 16:11:10
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
Progress as of : 1987-10-20

RESP CODE	TRADE	NAME	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	REMARKS
			OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	NOV	NOV	NOV	NOV	NOV	NOV	NOV	
			21	22	23	26	27	28	29	30	2	3	4	5	6	9	10	
02	SCAFFOLDING SUBTRADE	SCAFFOLDING INC.	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A								REMOVE EAST FACE
06	CABINETS SUBTRADE	KITCHEN CABINETS INC.	1	1	1	N/A	1	N/A	N/A	N/A								INSTALL 6th, 5th, 4th FLRS.
10	PAINTING SUBTRADE	PAINTERS INC.	2	2	2	2	2	5	5	5								PRIMING WALLS/CEILINGS.
11	TILES SUBTRADE	CERAMIC TILE INC.	3	3	3	3	3	2	3	2								INSTALLING TILES/MARBLE
12	ELEVATOR SUBTRADE	ELEVATOR INC.	2	N/A	2	2	1	1	1	1								INST. CONTROLS./ADJUST
15	PLUMBING SUBTRADE	MR PLUMBER	2	N/A	N/A	N/A	N/A	2	3	3								INST. R.W.L/FINISH PLUMB
16	ELECTRICAL SUBTRADE	MR ELECTRICAL	1	1	N/A	N/A	1	1	1	1								FINISH ELECT.
51	VENTILATION SUBTRADE	MR VENTILATION	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A								—
73	ROOFING AND WATERPROOFING SUB.	ROOFING INC.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A								—
G	GENERAL CONTRACTOR		3	3	3	3	3	3	3	5								FINISH CARPENTRY./[illegible]
																		—

Figure 2-43 (cont'd)

REPCON™

TIFFANY PLACE (43RD & YEW)

LINEAR PLANNING CHART

```
+----------------------------------+
K | *  critical act.                 |
E | p  act. has procurement seq.     |
Y | c  completed                     |
+----------------------------------+
```

Report Date : 1987-11-01
Report Time : 14:05:00
File Used : C:\REPCONC\TIF\TIF
Revision Number : 1
[redacted] of : 1987-10-30
Schedule Window
From 01OCT87 To 18DEC87
From LS To RF

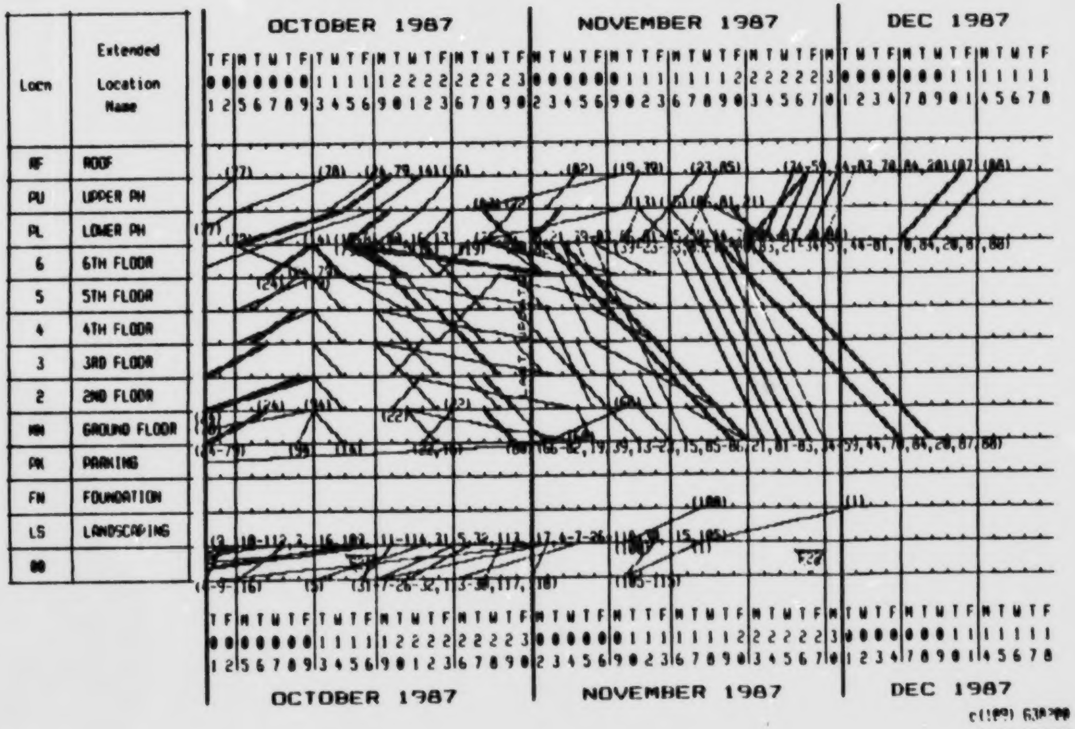


Figure 2-44 October 30, 1987 Schedule Update.

ACTIVITY KEY

	Act No	Type	Act Description
(1)	0121LS		LANDSCAPING
c(3)	022200		APPLY PAPER & MESH
(4)	022300		APPLY ACRYLIC FINSH
c(5)	022400		CAULK WINDOWS
(7)	023700		REMOVE SCAFFOLDING
c(9)	042200		CONNECT PERMANENT POWER
(13)	060100	N	KITCHEN CABINETS
*c(14)	060200	S	BATHROOM VANITIES
(15)	060300	P	KITCHEN CABINET TOPS
c(16)	060400	S	BATHROOM CABINET TOPS
*(19)	100100	S	PAINT UNDER/PRIMER/FINSH COATS
*(20)	100200	N	PAINT TOUCH-UP
*(21)	110100	N	KITCHEN CERAMIC TILES
c(22)	110200	N	INSTALL MARBLE ENTRANCES
(23)	110300	N	INSTALL TILE BALCONIES
*c(24)	110400	N	BATHROOM CERAMIC TILE
(26)	122200		ELEVATOR CONTROLS
(30)	122600		TEST ELEVATOR SYSTEM
c(31)	122700		INSTALL ELEVATOR CAB
c(32)	122800		ADJUST ELEVATOR DOORS
*(34)	150300	N	PLUMBING FINISHING
(39)	151000	S	FIRE CABINET HOSES/COVERS
*(44)	160300	N	ELECTRICAL FINISHING/FIXTURES
(59)	510500	N	VENTILATION FINISHING
(60)	5130PK		MECHANICAL ROOM
(66)	7373MN		WATERPROOFING EXT. MAIN SLAB
*(70)	920100	N	CARPETING
*c(77)	617100	N	DRYWALL
*c(78)	617200	S	GYPSUM JOINTS
*c(79)	617300	N	PLASTER CEILING
*c(80)	617400	N	HARDWOOD FLOORING
(81)	617500	S	FINISH HARDWOOD FLOORS
*(82)	618000	N	FINSH CARPENTRY I:TRIMS.CASING
*(83)	618100	N	FINSH CARPENTRY II: [illegible]
*(84)	618200	P	FINSH CARPENTRY III:DOORS
(85)	618300	N	BALCONY HANDRAILS & [illegible]
(86)	618400	S	INSTALL KITCHEN [illegible]
*(87)	619000	N	CLEAN APARTMENTS
*(88)	619100	N	REPAIR DEFICIENCIES
c(94)	620700		BACKFILL AROUND PERIMETER
(100)	0200LS		DRIVEWAY
(105)	[illegible]		INSTALL [illegible]
c(109)	638200		ELEVATOR VESTIBULE TAPE/FILL
c(110)	638300		CHIMNEY FRAMING
c(111)	638400		CHIMNEY GYPROC
c(112)	638500		CHIMNEY DUCTWORK
c(113)	638600		CHIMNEY STUCCO
c(114)	638700		METAL HANDRAILS-STAIRWELL
(115)	639000		INSTALL VIDEO SYSTEM
c(116)	639100		REMOVE TEMPORARY POWER BOX
c(117)	639200		CONNECT GAS METER
(118)	639300		INSTALL WATER SERVICE
*c(121)	6A0100		ELEVATOR CAB DAMAGE
(122)	6A0600		SHELL OCCUPANCY PERMIT

5. The old time superintendent is a barrier to improving the process. They resist change vigorously and are uncooperative in recording progress in a useful format. Training directed at changing entrenched attitudes is required as is training in how to use formalized reports.

6. Experience can be documented in electronic form and readily transferred from one job to the next. A core of activities which repeats from project to project exists.

7. Work continuity is important for several trades. In some cases, continuity of work is required for each activity. In other cases, continuity of work for the crew is most important, and work on individual activities can be interrupted as long as buffer activities exist.

8. Three different updating formats were field tested. Their success or lack of it was dependent on the cooperation of the superintendent. The most successful one was the field update report. Its only major problem was that it becomes lengthy when the high intensity finishing phase is reached and work is progressing on many floors at the same time.

9. When computerized scheduling was used and a free service was available, management sought considerable detail and refinement in the schedule. This detail is essential to treat coordination interfaces and pinpoint the source of problems and strategies to solve them. The benefits of detailed scheduling were demonstrated in case study two in terms of minimizing the time overrun.

10. The planning structures developed to treat repetitive work under a parallel research program demonstrated their power to treat easily changing location sequences and maintain a current schedule.

11. A well thought out and executed implementation strategy for computerized planning and scheduling is as important, if nor more so, as the particular system adopted if success is to be achieved. This strategy must emphasize training of all personnel, from the site superintendent to top management.

12. Conducting this kind of research is difficult and expensive. The researchers must have credibility and at times thick skins. They must be willing to insert themselves into the process and offer information of use to the project at hand if they are to gain meaningful insights and feedback from project personnel.

2.6 WHAT HAS HAPPENED TO THE FIRM

Since our association with the firm starting in 1986, it has now started its 8th high rise project. The size of these projects range from 11 stories to 31 stories.

Computerized scheduling has been performed in house since the start of January 1988. The firm is using the research system that was employed throughout this study. They have hired a masters level student specializing in construction management as a full time employee. He is responsible for the planning and scheduling of all projects.

Benefits obtained to date include much better control of schedule performance, improved relations with clients, and effective marketing of the firm's services.

The firm has recently sponsored a research project directed at improving daily site reporting and coding the experience base gained from its projects directly into the computer system in the form of an expert system. As part of this exercise, project superintendents and project managers are participating in a series of meetings aimed at capturing their knowledge base. Slowly but surely, they are acknowledging that benefits can accrue from formal planning and scheduling and that computers won't replace them so they need not feel so threatened. Clearly, patience, perseverance and continued training are essential for success.

JS has required that all projects be formally scheduled and updated regularly. He has organized several meetings with all management personnel for discussion of what the firm is trying to do and to demonstrate the commitment of the firm to more rigorous time management of projects.

JM has become a champion of computerized planning and scheduling and especially automated daily site reporting. He is making important contributions to the documentation of the firm's knowledge base.

BJ continues to resist change. He is sharing some of his vast knowledge as the expert system is being built. He is not hesitant, however, in expressing his skepticism.

RS continues to update regularly and is making valuable contributions to the knowledge base being built into the system.

CHAPTER 3: UPDATING

3.1 INTRODUCTION

Schedule updating for high-rise residential construction provides the focus of this chapter. The work described is directed at the goals of maintaining schedule currency and capturing knowledge in the most efficient manner.

Updating is defined as containing the following elements:

1) the capture of actual performance in terms of start and finish dates both for on and off-site activities, including % progress to date and time and cost to complete for activities in progress,
2) the documentation of problems, including recording of parameters that provide a context for actual performance,
3) incorporation of actual performance into activity, procurement, cash flow, labour and billing schedules,
4) forecasting the implications of performance to date,
5) revisions of one or more schedules to achieve stated goals, and
6) communication of revised schedules to project participants.

Thus, updating involves the recording of history, the exploration of its consequences for future actions, and changes in construction strategy to counteract problems to date and anticipated problems. In addition, updating enables one to capitalize on opportunities provided by better than expected performance and changed conditions.

This chapter is structured as follows. First, an extensive description of the ingredients of the updating problem is presented. Attention is then directed at effective means for capturing actual field performance information and the problems encountered in field tests of the concepts developed. The next section deals with automated daily site reporting. This concept parallels real time control processes used in the process industries and builds upon an existing standard practice in the construction industry; that of the superintendent's daily site report. The final section summarizes the findings of the chapter and presents suggestions for future work.

In conducting this work, a review of the literature was made, with little success. The problems are largely organizational, attitudinal and training ones, rather than technical. Consequently they have attracted little attention by construction engineering and management science researchers. Most reference material subscribes to the basic paradigm of plan, schedule, monitor and control with little acknowledgement of the practical difficulties of gathering actual performance data, interpreting it and following up on its consequences. However, there is scope for technical contributions in terms of the design and integration of site reports and data gathering formats with computer-based construction project management systems. A further technical contribution could be the design of "real" time feedback systems which are important for the development of expert based systems for planning, scheduling and control.

The state-of-the-art in terms of practice is poor, as described in Chapters 1 and 2 of this report. Updating in any consistent and complete way is seldom done. The consequences of this are a lack of any formal, current schedule after the early phases of a project and time overruns.

The methodology adopted for the work described here consisted of extensive discussions with field and project management personnel, the testing of three different field data gathering formats and their fine tuning, and preliminary testing of a partial prototype of an automated daily site reporting system which is being developed as part of a masters thesis.

3.2 INGREDIENTS OF THE UPDATING TASK

As indicated in the previous section, updating treats time, cost, value and quality information along with context information required for interpretation of progress. It is a process which intersects with several functions, including estimating, cost accounting, progress billing, change order control and time, labour, cash flow and procurement schedule maintenance. The challenge becomes how to exploit data gathered for one function to serve the needs of other functions.

We examine the updating task in general and describe current weaknesses in practice as they relate to the control of time. Attention is directed to performance for the individual activity. The implications of this performance for itself and other activities is handled through the network framework which links activities. Our analysis is in the context of a repetitive activity, the hallmark of high-rise residential construction. A repetitive activity is one which occurs at multiple locations in the project, for example drywall on every floor.

A comprehensive statement of the attributes of a repetitive activity provide a useful starting point. In practice, many of them are not stated explicitly and/or are not accurately defined. Deficiencies in current practice are highlighted. We divide the attributes into two groups, user specified and derived, and further divide information into preconstruction and construction phases.

It is important to keep in mind the constraints imposed by the jungle-like competitive conditions that exist in construction. Of necessity, the project management team of the general contractor is kept very small, with site staff consisting, at best, of a superintendent, an assistant and a foreman and at worst, the site superintendent by himself. The superintendent and foreman are action oriented, and treat paperwork with disdain. In addition, a project manager and other support staff (e.g.cost accounting) are resident in the main office and usually are responsible for other jobs as well. These constraints contribute to the deficiencies identified below. Other contributing factors are discussed later.

3.2.1 Preconstruction Planning

User specified activity attributes include the following:

1) A description and an implied scope of work - Attached to this scope of work are a number of operations with associated work quantities. For example, steel studding for drywall work includes floor layout, attachment of tracks and installation of vertical studs. Describing this scope of work are drawings and specifications which prescribe a standard of quality.

   In practice, scoping standards are lax from one project manager to another and from one project to another, despite significant similarities among most high-rise residential projects. Activity breakdowns are generally too coarse to be of much use for field coordination and progress measurement. This is especially true for subtrade work.

2) A responsibility code, both for supply of material and its installation.

3) A sequence of work locations for the repetitive activity. - e.g. start on second floor for studding, proceed progressively upward to the penthouse and then finish with the main floor.

   In practice, activities that are repetitive are seldom broken down location by location. While location sequences are usually discussed, they are seldom recorded in a formal way.

4) Requirements dealing with work continuity and the use of multiple crews (working on several locations simultaneously).

As a strategy for higher productivity, work continuity is subscribed to, but more in the context of maintaining continuous work for a crew than continuous work on an activity. While this may be satisfactory for situations where buffer activities exist, for some trades such activities do not exist. If a trade keeps running out of work, tradesmen are reallocated to other projects and severe difficulties can arise in getting them back. Consequently, subtrades will often refuse to start work until work continuity is assured. Insufficient discussion of the importance of continuity is held with subtrades when the schedule is being formulated. In many cases, schedule issues are not discussed at all during initial schedule formulation.

5) A set of durations, one for each location worked. These durations reflect different scopes of work for each location, learning curve effects, etc.

Useful estimating relationships for activity durations, especially for subtrade work, are lacking. The development of such relationships is hampered by a lack of meaningful feedback from the field and an absence of resources to develop the relationships, even if data were available.

6) A statement of work methods for each activity. For example, the use of flyforms for slabs; the use of a swing stage for exterior enclosure work instead of scaffolding, etc.

Most plans and schedules currently prepared do not include a statement of work methods which is important for comparative analysis of projects and meaningful use of past production information.

7) A set of predecessor activities, milestones, relationships and a set of successor activities.

For those cases where formal network modelling is used, scoping is incomplete and only obvious predecessor relationships are specified. Consequently, schedules can be inaccurate and floats wildly exaggerated, leading to low credibility of the schedule in the field and hence little if any reference or adherence to it.

8) A set of off-site activities (e.g. contract award, shop drawing preparation and approval, fabrication, delivery) that must be completed prior to on-site work.

In practice, formal preparation of procurement schedules for the project as whole is seldom done. As a result, materials are often not available when required, resulting in delays or the splitting of activities to maintain momentum.

9) Cost information (for the general's own work, labour, equipment, materials; for subtrade work, cost to general contractor) and price information (cost to client), including distributions of cost and price over activity locations - Difficulties often arise in trying to assign costs to activities because no one to one relationship exists, in general, between the estimate breakdown and the activity breakdown.

Usually, subtrades are not compelled to provide their price breakdown in a format that parallels the activity breakdown. This creates difficulties in measuring progress and diverts project management attention away from more pressing problems. It also makes difficult the accurate assessment of cash flows.

10) Resource usage information, such as number of men per crew.

Seldom is crew size information for subtrade activities requested. The name of the foreman for key trades is often requested, however. Such information can be obtained, and using it, manpower profiles for each trade can be generated. These profiles can then be used to monitor actual manpower use, permitting the speedy identification of undermanning or overmanning situations which may affect successor activities or procurement sequences.

11) A time distribution of expenditure over the length of the activity (in practice, normally a linear relationship is assumed between time and expenditure and value earned).

Derived activity attributes include the following:

1) Early start and finish dates, late start and finish dates (scheduled dates if input by user) and total and scheduled float.

   As stated earlier, use of only a partial logic set yields exaggerated estimates of float, severely lessening the credibility of the schedule.

2) Procurement sequence dates.

   In practice, detailed break-out of procurement sequences is seldom done, with the responsibility being transferred largely to the subtrades, with minimal checking by the general contractor.

In summary, the user specified attributes are all estimates based on past experience and knowledge of the project at hand, including members of the project team and market conditions. If care is exercised in estimating the attributes of all activities and the set of activities is complete, then one can have reasonable confidence in the benchmarks established. We have noted above and in Chapters 1 and 2 that insufficient care is used in producing these estimates, for a number of reasons.

3.2.2 Construction Phase

In the construction phase, at any given time, an activity has one of three status states: not started; in progress; and completed. Each of these situations can require analysis and changes to the activity. We restrict our attention to activities in progress and identify relationships with activities yet to come and those already completed. Again, we treat the activity in terms of user specified inputs and derived ones, and note current practices, including deficiencies and unresolved problems. Inadequate reporting from the field is highlighted.

3.2.2.1 User Specified Attributes for Activity in Progress

These are discussed in terms of the attributes of the work performed to date and modification of the attributes of the work left to complete. They include the following:

1) The description and scope of the activity may have changed. For example, studding may now be subdivided into interior and exterior studding, resulting in changes in productions rates, sequencing, crewing, etc.

   As a general observation, activities are often subdivided into multiple passes to work around problems, despite the inefficiencies that result from such strategies. This division of activities is virtually never recorded. If the original scope of work for the activity was too coarse (highly aggregated - eg. all mechanical work is represented by one activity) to allow for proper coordination and measurement of work, additional activities may be added. This shows up currently in comments on work done in the superintendent's daily site report. Seldom are such divisions/additions incorporated into the project schedule.

2) Responsibility for supply or install or both may be reassigned with resultant contract amendments.

3) Location sequences may have changed. This problem is especially relevant to the finishing phases of a project, when sales govern the timing of unit readiness.

   Seldom are changes in location sequence reported (in part because of the belief that things will get back on track). As a result, the consequences for successor activities are not explored. This leads to conflicts with subtrades because the efficiency of their work is affected, and to procurement problems because of the difficulty in changing fabrication/manufacturing schedules.

In addition, standard CPM network representations are very difficult to maintain when location sequences are significantly changed. One is either forced to relabel all successor activities or alter logic, both of which are very time consuming. Use of planning objects developed under a complementary research program have removed much of this updating burden (see case study in Chapter 2).

4) The subtrade responsible for the activity may have refused to start until sufficient work was ready to ensure work continuity.

Difficulties with subtrades such as the so-called comeback problem which result, in many cases, from lack of work continuity are often recorded in field reports (e.g. no men today or only 2 men for subtrade ABC). However, explanations of the root cause of no manpower are not recorded. Of even greater significance is the lack of recording revised start dates worked out with the subtrades. Consequently, accurate updating of the schedule cannot be done, so downstream problems are not detected in a timely fashion.

5) Actual start and finish dates of an activity are seldom recorded, and for activities in progress, projected completion dates are not reported. This is the minimal information required for meaningful updating. If work is taking more or less time than anticipated, factors leading to this performance are only available in broad brush terms - e.g. poor weather, site storage a problem, insufficient manpower. Such factors are seldom assigned against individual activities.

A key issue is what use should be made, if any, of production rates achieved to date, in estimating time to complete for the location at hand and for all remaining locations. From a control perspective, if the original durations are achievable, effort should be directed at meeting them as opposed to adjusting durations for activities yet to come to reflect performance to date. This issue has implications for the design of automated updating systems. Our response in handling this issue has been to provide management with forecast average duration to date and actual average duration to date and allow them to make the decision regarding adjustment of remaining durations.

6) Commentary on activity work methods, if recorded at all, appears on daily site reports which go unanalyzed. Consequently, many small but useful innovations in work methods cannot be capitalized upon for future projects.

7) Often, activities are commenced out of sequence, either because the work is subdivided, the original logic was preferred but not essential or the original modelling was incorrect. Out of sequence work tends to be the norm, not the exception. Logic changes are almost never recorded or noted in field reports. The issue then becomes how to detect such changes automatically from date information.

8) Percent complete in terms of supply and install for locations worked and in progress, are estimated for billing purposes. Identification of deficiencies in terms of quality is not well done. Difficulties arise because the breakdown used for billing does not generally correspond to the schedule breakdown. Cost to complete for general contractor work poses difficulties in that knowledge of resources expended to date is required (which is never available in a timely fashion) and estimates must be made of resource expenditures (manpower, equipment, materials) yet to come.

9) Resource usage in terms of manpower and equipment at the individual activity level is very hard to assess, although project superintendents make a noble effort to cost code general contractor work. Aggregate manpower levels for subtrades, if recorded at all in the daily site report, are not analyzed. Seldom are comments recorded regarding skill levels or the deployment of manpower throughout the project.

A recurring theme in the above observations is that inadequate recording of actual performance data thwarts proper updating of the schedule and capture of knowledge for use on future projects. Responses to this problem are addressed in the following sections.

3.3 APPROACHES TO GATHERING FIELD PERFORMANCE INFORMATION

In this section, we examine approaches to gathering information essential to the updating process. The approach taken is to address the needs of the project superintendent for schedule information and have him record actual performance on these schedule formats - hardly a new concept. The difference comes in that all site schedules are computer driven from the project schedule, and attention is directed at short time intervals and only the most important activity attributes.

Three data formats are identified:

1) work location schedule;
2) field update schedule; and
3) matrix short cycle schedule.

The design of each of these is described in terms of how the formats respond to the needs and deficiencies identified in section 3.2. Actual experience from use of these formats is also discussed.

3.3.1 Work Location Short Cycle Schedule

The concept for this format came from direct interaction with a superintendent on a luxury condominium project. The format is shown in figure 3.1. Note the following features.

Activities are displayed in the form of a bar chart which spans a user specified time window of 15 days. They can be sorted according to responsibility code first and then scheduled start, allowing a work location report to be generated for each and every subtrade, or by scheduled start with intermixing of responsibility codes. Activities are represented in the bar chart format by the physical location(s) on which they are scheduled to be active (the P for planned row). Allowance for recording actual performance and/or revisions is provided in the A line.

For each responsibility code, allowance is made for the insertion of additional work (see blank line). Activities that are critical are flagged. The option exists to include a manpower usage data collection form on which each subtrade scheduled to be active in the 15 day time window is included. If desired, forecast manpower usage can be included for easy detection of undermanning or overmanning. Allowance is also made for remarks on subtrade performance (e.g. skill levels, etc.).

The format provides the superintendent with a working tool with which to coordinate work and pace the process. His data recording duties are limited to recording each day the status of an activity (where it is in progress, if at all), adding any activities not formally listed, and recording manpower counts for the subtrades. At most a 5-10 minute commitment per day. If the report is to be submitted for project level schedule updating, the only additional information required is forecast completion dates for activities in progress and revisions, if any, to start dates for upcoming activities. No requests are made for logic information, changed location sequences (except as detected from work done to date), explanatory remarks, etc.

From a computer processing viewpoint, actual start and finish dates can be readily detected, as can changes in logic and location sequences. For these cases, logic no longer applicable can be deleted and the assumption can be made that remaining work will be performed according to the originally specified sequence unless instructions to the contrary are made.

Requirements for extensive information have been sacrificed for simplicity of representation, use and data gathering. The report has been favourably reviewed by superintendents. Nevertheless, it has not been successful as a data gathering format. The only success enjoyed to date is when the project manager sits with the superintendent and fills it out with him. This has been the case on several projects.

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YOUR CONSTRUCTION COMPANY                                                                                     REPCON™

                                      REPCON SAMPLE HIGHRISE PROJECT
                                                                                                            Page 1 of 2
                                    WORK LOCATION SHORT CYCLE SCHEDULE

                                  +------------------------+                       Report Date     : 1988-10-22
                                  K| * critical activity   |                       Report Time     : 09:32:41
                                  E| M number of men       |                       File Used       : C:\VERSION1\PROJ02\SAMPLE
                                  Y| P planned work location|                      Revision Number : 0
                                   | A actual work location |                      Progress as of  :
                                  +------------------------+                       Schedule Window
                                                                                     From 7 NOV88 to 28 NOV88
                                                                                     From AP To S2

************************************************************************************************************************************************************************
TRADE / ACTIVITY                  | | NOV 7  | NOV 8  | NOV 9  | NOV 10 | NOV 14 | NOV 15 | NOV 16 | NOV 17 | NOV 18 | NOV 21 | NOV 22 | NOV 23 | NOV 24 | NOV 25 | NOV 28 |
                                  | |   M    |   T    |   W    |   T    |   M    |   T    |   W    |   T    |   F    |   M    |   T    |   W    |   T    |   F    |   M    |
************************************************************************************************************************************************************************
REINFORCING STEEL                 |M|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
   040100 REINFORCE STRUCTURE     |P|9       |9       |9       |        |10      |10      |10      |        |        |MF      |MF      |        |PH      |PH      |PH      |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                                  |P|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
************************************************************************************************************************************************************************
PRECAST CONCRETE                  |M|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
   100100 INSTALL PRECAST PANELS  |P|        |        |        |        |2 3     |2 3     |2 3     |4 5     |4 5     |4 5     |        |        |        |        |        |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                                  |P|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
************************************************************************************************************************************************************************
WINDOWS AND EXTERIOR DOORS        |M|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
   110100 INSTALL WINDOWS & DOORS |P|        |        |        |        |        |        |        |2       |2       |2       |3       |3       |3       |4       |4       |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                                  |P|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
************************************************************************************************************************************************************************
MECHANICAL (PLUMBING,VENTILATION) |M|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
   150200 ROUGH-IN VENTILATION SYSTEM |P|3   |3       |3       |3       |4       |4       |4       |4       |5       |5       |5       |5       |6       |6       |6       |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
   150100 ROUGH-IN SPRINKLER SYSTEM |P|MN    |MN      |2       |2       |2       |2       |3       |3       |3       |3       |4       |4       |4       |4       |5       |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
                                  |P|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
************************************************************************************************************************************************************************
ELECTRICAL                        |M|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
   160100 ELECT CONDUIT IN STRUCTURE |P|9     |9       |9       |        |10      |10      |10      |        |        |MF      |MF      |        |        |PH      |PH      |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
   162202 INSTALL ELECTRICAL ROOM |P|   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |   B2   |
                                  |A|        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
------------------------------------------------------------------------------------------------------------------------------------------------------------------------
```

Figure 3-1 Work Location Short Cycle Schedule

TRADE / ACTIVITY		NOV 7	NOV 8	NOV 9	NOV 10	NOV 14	NOV 15	NOV 16	NOV 17	NOV 18	NOV 21	NOV 22	NOV 23	NOV 24	NOV 25	NOV 28
		M	T	W	T	M	T	W	T	F	M	T	W	T	F	M
160200 ELECTRICAL ROUGH-IN	P								B2	B2	B2	B2	B2	B2	B1	B1
	A															
	P															
	A															
GENERAL CONTRACTOR	M															
030100 FORM & POUR SUPERSTRUCTURE	P	9	9	9	10	10	10	10	RF	RF	RF	RF	PH	PH	PH	PH
	A															
	P															
	A															

Figure 3-1 (Cont'd) Work Location Short Cycle Schedule

```
YOUR CONSTRUCTION COMPANY                                                                                    REPCON™

                                        REPCON SAMPLE HIGHRISE PROJECT
                                                                                                             Page 1 of 1
                                WORK LOCATION SHORT CYCLE SCHEDULE : MANPOWER USAGE

                                                 R+-------------+                          Report Date     : 1988-10-22
                                                 E| F Forecast  |                          Report Time     : 09:33:06
                                                 Y| A Actual    |                          File Used       : C:\VERSION1\PROJ02\SAMPLE
                                                  +-------------+                          Revision Number : 0
                                                                                           Progress as of  :

||-----------------------------------------------------------------------------------------------------------------------------||
||RESP||           TRADE             ||             NAME             || ||M|T|W|T;M|T|W|T|F;M|T|W|T|F;M||                    ||
||CODE||                             ||                              || ||NOV|NOV|NOV|NOV;NOV|NOV|NOV|NOV|NOV;NOV|NOV|NOV|NOV|NOV;NOV|| REMARKS ||
||    ||                             ||                              || || 7 | 8 | 9 |10 ;14 |15 |16 |17 |18 ;21 |22 |23 |24 |25 ;28 ||              ||
||-----------------------------------------------------------------------------------------------------------------------------||
|| 04 ||REINFORCING STEEL            ||ART'S REINFORCING             ||F||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||    ||                             ||                              ||A||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||-----------------------------------------------------------------------------------------------------------------------------||
|| 10 ||PRECAST CONCRETE             ||CONFORCE PRECASTERS           ||F||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||    ||                             ||                              ||A||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||-----------------------------------------------------------------------------------------------------------------------------||
|| 11 ||WINDOWS AND EXTERIOR DOORS   ||CLEAR-SIGHT INC.              ||F||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||    ||                             ||                              ||A||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||-----------------------------------------------------------------------------------------------------------------------------||
|| 15 ||MECHANICAL (PLUMBING,VENTILATION) ||SMITH & JONES MECHANICAL ||F||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||    ||                             ||                              ||A||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||-----------------------------------------------------------------------------------------------------------------------------||
|| 16 ||ELECTRICAL                   ||LIGHTNING ELECTRICAL INC.     ||F||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||    ||                             ||                              ||A||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||-----------------------------------------------------------------------------------------------------------------------------||
||  0 ||GENERAL CONTRACTOR           ||YOUR CONSTRUCTION COMPANY LTD ||F||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||    ||                             ||                              ||A||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||-----------------------------------------------------------------------------------------------------------------------------||
||    ||                             ||                              || ||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||    ||                             ||                              || ||   |   |   |   ;   |   |   |   |   ;   |   |   |   |   ;   ||              ||
||-----------------------------------------------------------------------------------------------------------------------------||
```

Figure 3-1 (Cont'd) Work Location Short Cycle Schedule

What is the reason for the failure, which is greatest for old time superintendents? Our view is that there are several contributing reasons. It constitutes one more report that the superintendent must complete and it provides information to senior management not only on the project performance but on the superintendent's performance as a manager. In addition, senior management is reluctant to enforce completion of the report, even when field performance is poor and the client is not satisfied, so the superintendent sees that the commitment is weak. Also, the project manager is seen to be the main beneficiary of the updating, so he should do the work.

3.3.2 Field Update Report

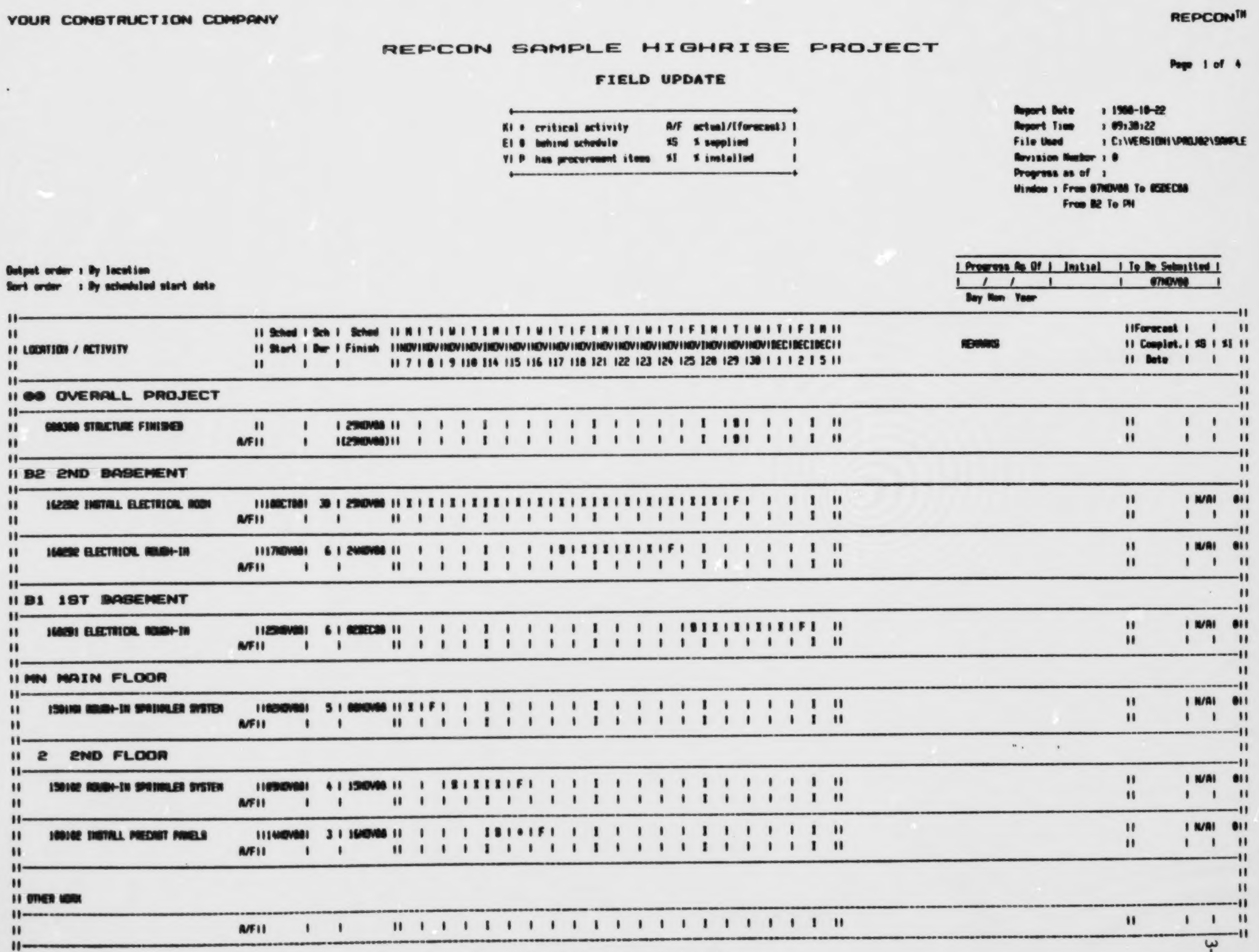
The format of this report is shown in figure 3.2. The main difference between it and the previous one is treatment of more of the attributes of the activity and a twenty day time frame. Each location of each activity appears on a separate line. Individual reports can be produced for each subtrade, an overall project report can be produced (sorted by responsibility code or work location) or reports can be produced for specific groupings of work locations (useful for multi-building projects). Allowance is made for the recording of actual start and finish dates, remarks, forecast completion dates, and % supplied and % installed for progress billing purposes. A manpower usage report can be appended for recording actual manpower loading. Again, the daily time commitment required to record information is 10-15 minutes.

Positive feedback on the use of this report has been received from several sites, but more from heavy civil engineering projects than high-rise residential ones. A younger, more schedule oriented superintendent used it on a small residential project (see case study, Chapter 2) and derived significant benefits from it. He has continued to make use of the format on his next project. In general, however, it has not enjoyed much more success than the work location report, basically for the same reasons cited before. It has the additional disadvantage that as a project grows in size and intense work phases are entered (e.g. the finishing phase), the report spans several pages, making it somewhat unwieldy.

3.3.3 Short Cycle Matrix Format

This report format is depicted in figure 3.3. Its shape is meant to parallel that of the building itself, with rows corresponding to work locations and columns corresponding to activities. It is possible to suppress schedule information that falls outside of the time window selected to reduce the amount of information shown (see figure 3.3). Allowance is made for the capture of actual start and finish dates, percent supplied and installed for activities in progress, projected completion dates and revised start dates for activities yet to come, and remarks. Again, only 5-10 minutes are required for recording the days activities.

The report has proved useful to the project manager for gathering information for progress billings because it provides a checklist with which the building can be walked. However, its somewhat unconventional format has not gained acceptance from superintendents in terms of day-to-day use, although they have expressed interest in it and additional attempts to use it are warranted. One improvement to it worth considering is the addition of time contours - for example, weekly time contours. They would help field staff pinpoint ongoing activities more quickly.



```
YOUR CONSTRUCTION COMPANY                                                                                              REPCON(TM)

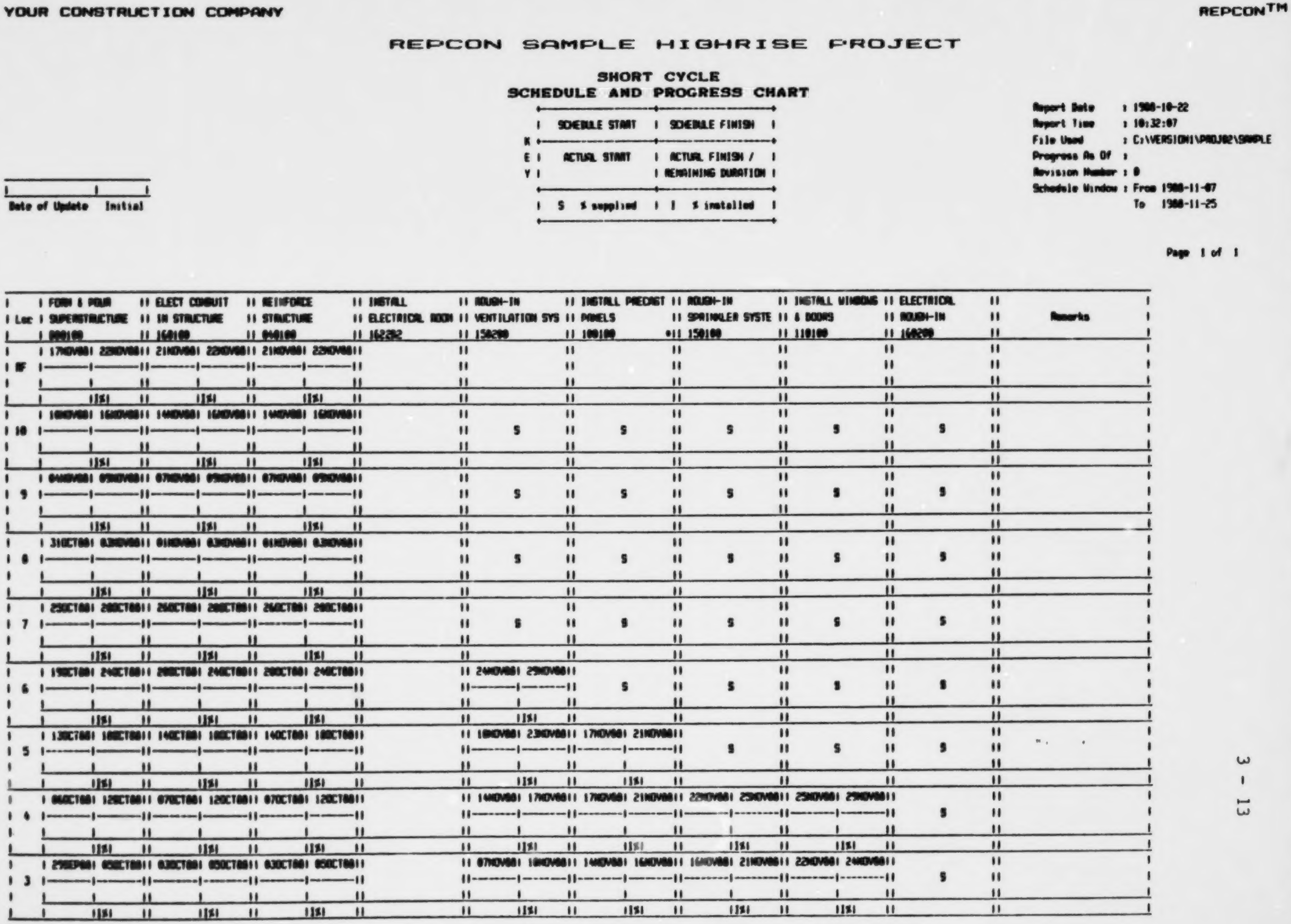
                                     REPCON SAMPLE HIGHRISE PROJECT
                                                                                                                       Page 1 of 4
                                              FIELD UPDATE
                                                                                           Report Date      : 1988-10-22
                                 +--------------------------------------------------+      Report Time      : 09:30:22
                                 K| * critical activity      A/F  actual/(forecast) |      File Used        : C:\VERSION1\PROJ02\SAMPLE
                                 E| B behind schedule        %S   % supplied        |      Revision Number  : 0
                                 Y| P has procurement items  %I   % installed       |      Progress as of   :
                                 +--------------------------------------------------+      Window : From 07NOV88 To 05DEC88
                                                                                                  From B2 To PH

                                                                                    ______________________________________________
Output order : By location                                                          | Progress As Of |  Initial  | To Be Submitted |
Sort order   : By scheduled start date                                              |   /   /        |           |     07NOV88     |
                                                                                      Day Mon  Year
||--------------------------------------------------------------------------------------------------------------------------------||
||                               || Sched | Sch |  Sched  || M | T | W | T | M | T | W | T | F | M | T | W | T | F | M | T | W | T | F | M ||           ||Forecast |    |    ||
|| LOCATION / ACTIVITY           || Start | Dur | Finish  ||NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|DEC|DEC|DEC|| REMARKS   || Complet.| %S | %I ||
||                               ||       |     |         || 7 | 8 | 9 |10 |14 |15 |16 |17 |18 |21 |22 |23 |24 |25 |28 |29 |30 | 1 | 2 | 5 ||           ||  Date   |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
|| 00 OVERALL PROJECT                                                                                                             ||
||--------------------------------------------------------------------------------------------------------------------------------||
||    000300 STRUCTURE FINISHED  ||       |     | 29NOV88 ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | B |   |   |   |   ||           ||         |    |    ||
||                            A/F||       |     |(29NOV88)||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | B |   |   |   |   ||           ||         |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
|| B2 2ND BASEMENT                                                                                                                ||
||--------------------------------------------------------------------------------------------------------------------------------||
||    162202 INSTALL ELECTRICAL ROOM ||10OCT88| 30 | 28NOV88 || X | X | X | X | X | X | X | X | X | X | X | X | X | X | F |   |   |   |   |   ||           ||         |N/A | 0  ||
||                            A/F||       |     |         ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
||    160202 ELECTRICAL ROUGH-IN ||17NOV88|  6  | 24NOV88 ||   |   |   |   |   |   |   | B | X | X | X | X | F |   |   |   |   |   |   |   ||           ||         |N/A | 0  ||
||                            A/F||       |     |         ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
|| B1 1ST BASEMENT                                                                                                                ||
||--------------------------------------------------------------------------------------------------------------------------------||
||    160201 ELECTRICAL ROUGH-IN ||25NOV88|  6  | 02DEC88 ||   |   |   |   |   |   |   |   |   |   |   |   |   | B | X | X | X | X | F |   ||           ||         |N/A | 0  ||
||                            A/F||       |     |         ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
|| MN MAIN FLOOR                                                                                                                  ||
||--------------------------------------------------------------------------------------------------------------------------------||
||    150100 ROUGH-IN SPRINKLER SYSTEM ||02NOV88| 5 | 08NOV88 || X | F |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |N/A | 0  ||
||                            A/F||       |     |         ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
||  2  2ND FLOOR                                                                                                                  ||
||--------------------------------------------------------------------------------------------------------------------------------||
||    150102 ROUGH-IN SPRINKLER SYSTEM ||09NOV88| 4 | 15NOV88 ||   |   | B | X | X | F |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |N/A | 0  ||
||                            A/F||       |     |         ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
||    100102 INSTALL PRECAST PANELS ||14NOV88| 3 | 16NOV88 ||   |   |   |   | B | * | F |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |N/A | 0  ||
||                            A/F||       |     |         ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
||                                                                                                                                ||
|| OTHER WORK                                                                                                                     ||
||--------------------------------------------------------------------------------------------------------------------------------||
||                            A/F||       |     |         ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||           ||         |    |    ||
||--------------------------------------------------------------------------------------------------------------------------------||
```

Figure 3-2 Field Update Report

```
||----------------------------------------------------------------------------------------------------------------------------------------------||
||                                     || Sched | Sch | Sched  || M | T | W | T | M | T | W | T | F | M | T | W | T | F | M | T | W | T | F | M ||                     ||Forecast |     |    ||
|| LOCATION / ACTIVITY                 || Start | Dur | Finish ||NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|NOV|DEC|DEC|DEC||      REMARKS        || Complet.| %S  | %I ||
||                                     ||       |     |        || 7 | 8 | 9 |10 |14 |15 |16 |17 |18 |21 |22 |23 |24 |25 |28 |29 |30 | 1 | 2 | 5 ||                     || Date    |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    110102 INSTALL WINDOWS & DOORS   ||17NOV88|  3  | 21NOV88||   |   |   |   |   |   |   | S | X | F |   |   |   |   |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    120102 INSTALL STEEL STUDDING    ||29NOV88|  4  | 02DEC88||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | S | X | X | F |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    160202 ELECTRICAL ROUGH-IN       ||05DEC88|  6  | 12DEC88||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | S ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
|| 3   3RD FLOOR                                                                                                                                  ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    150203 ROUGH-IN VENTILATION SYSTEM ||07NOV88|  4  | 10NOV88|| S | X | X | F |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    100103 INSTALL PRECAST PANELS    ||14NOV88|  3  | 16NOV88||   |   |   |   | S | * | F |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    150103 ROUGH-IN SPRINKLER SYSTEM ||16NOV88|  4  | 21NOV88||   |   |   |   |   |   | S | X | X | F |   |   |   |   |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    110103 INSTALL WINDOWS & DOORS   ||22NOV88|  3  | 24NOV88||   |   |   |   |   |   |   |   |   |   | S | X | F |   |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    120103 INSTALL STEEL STUDDING    ||05DEC88|  4  | 08DEC88||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | S ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
|| 4   4TH FLOOR                                                                                                                                  ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    150204 ROUGH-IN VENTILATION SYSTEM ||14NOV88|  4  | 17NOV88||   |   |   |   | S | X | X | F |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    100104 INSTALL PRECAST PANELS    ||17NOV88|  3  | 21NOV88||   |   |   |   |   |   |   | S | * | F |   |   |   |   |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    150104 ROUGH-IN SPRINKLER SYSTEM ||22NOV88|  4  | 25NOV88||   |   |   |   |   |   |   |   |   |   | S | X | X | F |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    110104 INSTALL WINDOWS & DOORS   ||25NOV88|  3  | 29NOV88||   |   |   |   |   |   |   |   |   |   |   |   |   | S | X | F |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
|| 5   5TH FLOOR                                                                                                                                  ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||    100105 INSTALL PRECAST PANELS    ||17NOV88|  3  | 21NOV88||   |   |   |   |   |   |   | S | * | F |   |   |   |   |   |   |   |   |   |   ||                     ||         | N/A |  0 ||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||                                                                                                                                                ||
|| OTHER WORK                                                                                                                                     ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
||                                 A/F ||       |     |        ||   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   ||                     ||         |     |    ||
||----------------------------------------------------------------------------------------------------------------------------------------------||
```

Figure 3-2 (Cont'd) Field Update Report



```
YOUR CONSTRUCTION COMPANY                                                                                                     REPCON™

                                            REPCON SAMPLE HIGHRISE PROJECT

                                                      SHORT CYCLE
                                             SCHEDULE AND PROGRESS CHART
                                             +-------------------+-------------------+
                                             | SCHEDULE START    | SCHEDULE FINISH   |                  Report Date     : 1988-10-22
                                           K +-------------------+-------------------+                  Report Time     : 10:32:07
                                           E | ACTUAL START      | ACTUAL FINISH /   |                  File Used       : C:\VERSION1\PROJ02\SAMPLE
                                           Y |                   | REMAINING DURATION|                  Progress As Of  :
 _______________________                     +-------------------+-------------------+                  Revision Number : 0
|            |          |                    | S  % supplied     | |  % installed    |                  Schedule Window : From 1988-11-07
Date of Update   Initial                     +-------------------+-------------------+                                    To   1988-11-25

                                                                                                                          Page  1 of  1

|    | FORM & POUR      || ELECT CONDUIT    || REINFORCE        || INSTALL          || ROUGH-IN         || INSTALL PRECAST  || ROUGH-IN         || INSTALL WINDOWS  || ELECTRICAL       ||                  |
| Loc| SUPERSTRUCTURE   || IN STRUCTURE     || STRUCTURE        || ELECTRICAL ROOM  || VENTILATION SYS  || PANELS           || SPRINKLER SYSTE  || & DOORS          || ROUGH-IN         ||     Remarks      |
|____| 080100           || 160100           || 040100           || 162202           || 150200           || 100100          *|| 150100           || 110100           || 160200           ||                  |
|    | 17NOV88| 22NOV88|| 21NOV88| 22NOV88|| 21NOV88| 22NOV88||                 ||                 ||                 ||                 ||                 ||                 ||                 |
| BF |--------|--------||--------|--------||--------|--------||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|    |________|________||________|________||________|________||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|    | 10NOV88| 16NOV88|| 14NOV88| 16NOV88|| 14NOV88| 16NOV88||                 ||                 ||                 ||                 ||                 ||                 ||                 |
| 10 |--------|--------||--------|--------||--------|--------||                 ||        S        ||        S        ||        S        ||        S        ||        S        ||                 |
|    |________|________||________|________||________|________||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|    | 04NOV88| 09NOV88|| 07NOV88| 09NOV88|| 07NOV88| 09NOV88||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|  9 |--------|--------||--------|--------||--------|--------||                 ||        S        ||        S        ||        S        ||        S        ||        S        ||                 |
|    |________|________||________|________||________|________||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|    | 31OCT88| 03NOV88|| 01NOV88| 03NOV88|| 01NOV88| 03NOV88||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|  8 |--------|--------||--------|--------||--------|--------||                 ||        S        ||        S        ||        S        ||        S        ||        S        ||                 |
|    |________|________||________|________||________|________||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|    | 25OCT88| 28OCT88|| 26OCT88| 28OCT88|| 26OCT88| 28OCT88||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|  7 |--------|--------||--------|--------||--------|--------||                 ||        S        ||        S        ||        S        ||        S        ||        S        ||                 |
|    |________|________||________|________||________|________||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||                 ||                 ||                 ||                 ||                 ||                 |
|    | 19OCT88| 24OCT88|| 20OCT88| 24OCT88|| 20OCT88| 24OCT88||                 || 24NOV88| 29NOV88||                 ||                 ||                 ||                 ||                 |
|  6 |--------|--------||--------|--------||--------|--------||                 ||--------|--------||        S        ||        S        ||        S        ||        S        ||                 |
|    |________|________||________|________||________|________||                 ||________|________||                 ||                 ||                 ||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||        ||%|     ||                 ||                 ||                 ||                 ||                 |
|    | 13OCT88| 18OCT88|| 14OCT88| 18OCT88|| 14OCT88| 18OCT88||                 || 18NOV88| 23NOV88|| 17NOV88| 21NOV88||                 ||                 ||                 ||                 |
|  5 |--------|--------||--------|--------||--------|--------||                 ||--------|--------||--------|--------||        S        ||        S        ||        S        ||                 |
|    |________|________||________|________||________|________||                 ||________|________||________|________||                 ||                 ||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||        ||%|     ||        ||%|     ||                 ||                 ||                 ||                 |
|    | 06OCT88| 12OCT88|| 07OCT88| 12OCT88|| 07OCT88| 12OCT88||                 || 14NOV88| 17NOV88|| 17NOV88| 21NOV88|| 22NOV88| 25NOV88|| 25NOV88| 29NOV88||                 ||                 |
|  4 |--------|--------||--------|--------||--------|--------||                 ||--------|--------||--------|--------||--------|--------||--------|--------||        S        ||                 |
|    |________|________||________|________||________|________||                 ||________|________||________|________||________|________||________|________||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||        ||%|     ||        ||%|     ||        ||%|     ||        ||%|     ||                 ||                 |
|    | 29SEP88| 05OCT88|| 03OCT88| 05OCT88|| 03OCT88| 05OCT88||                 || 07NOV88| 10NOV88|| 14NOV88| 16NOV88|| 16NOV88| 21NOV88|| 22NOV88| 24NOV88||                 ||                 |
|  3 |--------|--------||--------|--------||--------|--------||                 ||--------|--------||--------|--------||--------|--------||--------|--------||        S        ||                 |
|    |________|________||________|________||________|________||                 ||________|________||________|________||________|________||________|________||                 ||                 |
|____|        ||%|     ||        ||%|     ||        ||%|     ||                 ||        ||%|     ||        ||%|     ||        ||%|     ||        ||%|     ||                 ||                 |
```

Figure 3-3 Matrix Short Cycle Schedule and Progress Chart

Page 1 a

Loc	FORM & POUR SUPERSTRUCTURE 080100	ELECT CONDUIT IN STRUCTURE 160100	REINFORCE STRUCTURE 040100	INSTALL ELECTRICAL ROOM 162202	ROUGH-IN VENTILATION SYS 150200	INSTALL PRECAST PANELS 100100	ROUGH-IN SPRINKLER SYSTE 150100	INSTALL WINDOWS & DOORS 110100	ELECTRICAL ROUGH-IN 160200	Remarks
2	19SEP88 28SEP88 S	22SEP88 28SEP88 S	22SEP88 28SEP88 S		01NOV88 04NOV88 S	14NOV88 16NOV88 S	09NOV88 15NOV88 S	17NOV88 21NOV88 S	S	
HB	02SEP88 16SEP88 S	08SEP88 16SEP88 S	08SEP88 16SEP88 S		24OCT88 31OCT88 S	S	02NOV88 08NOV88 S	S	S	
B1					12OCT88 21OCT88 S		24OCT88 01NOV88 S		25NOV88 02DEC88 S	
B2				18OCT88 25NOV88 S	29SEP88 11OCT88 S		12OCT88 28OCT88 S		17NOV88 24NOV88 S	
FN										

Figure 3-3 (Cont'd) Matrix Short Cycle Schedule and Progress Chart

3.3.4 Conclusions

In summary, all three reports have been extensively tested on a number of projects. Interestingly, they have provided the only short term detailed schedules available at the site. Site personnel generated none for their own use. From time to time, the report format provided the basis for discussing construction strategy, particularly for subtrade work.

Despite such demonstrations of usefulness, for the firm with which most of the field testing was conducted for residential projects, only one superintendent out of five recorded performance data in any consistent way. And this was also despite the fact the larger projects were all behind schedule. During the extended time period of the field trials with this firm, senior management made clear to project staff the commitment of the firm to computerized control of projects and the significant benefits it was receiving. Nevertheless, despite pleading and cajoling by the president himself, the old-time superintendents have proved to be immovable objects in terms of providing the data required for proper schedule updating.

3.4 AUTOMATED DAILY SITE REPORTING

Experience to date indicates that the introduction of additional reports to the site management process for data gathering is not a viable approach, given present attitudes and constraints on the number of management resources that can be assigned because of competitive pressures. The challenge thus becomes how to use existing reporting frameworks to satisfy schedule updating requirements and to capture knowledge for use on future projects.

One report that is present on virtually every project is the superintendent's daily site report. In general, completion of these reports is done poorly, and little if any use is made of them except in claims situations, at which time it is usually discovered that the data recorded is of little use because of incompleteness and lack of consistent terminology from one day to the next.

The extent of the data requested on these forms by senior management ranges from a few categories (see figure 3.4) to very detailed requests for information (see figure 3.5). Both extremes receive the same response from the superintendent - minimal information. We have observed on several occasions a refusal by the superintendent to complete the standard company form. Instead, the superintendent maintains his own diary which he keeps to himself.

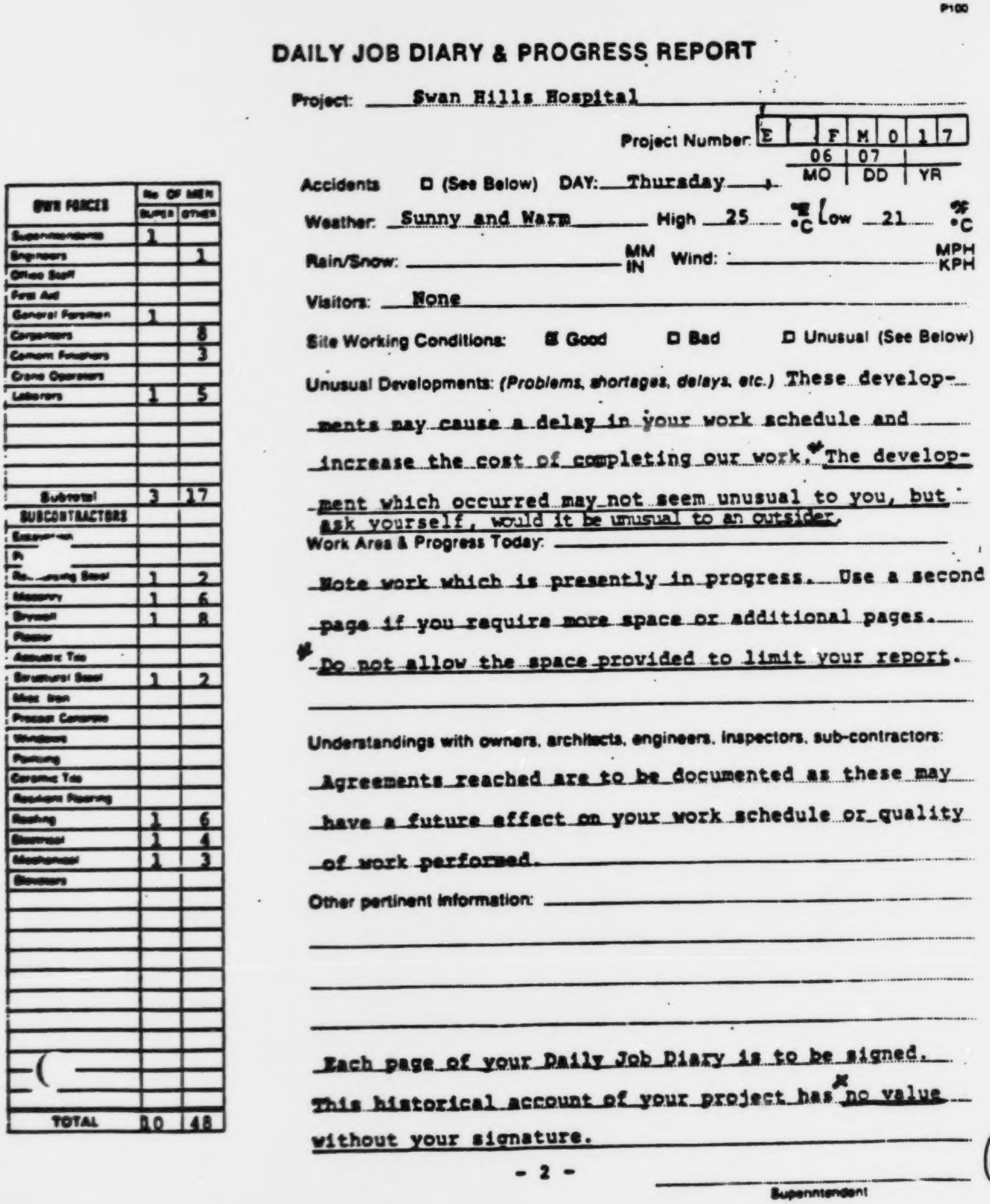
Discussions with senior management of several firms point to two reasons attempts are made to maintain such reports. First, keep the superintendent on his toes and, second, in case of claims, hopefully relevant information has been recorded. However, we have yet to see strong emphasis placed on the importance of properly completing the forms. Again, this lack of commitment by senior management signals to site personnel that this type of record keeping has low priority.

Nevertheless, over the longer term, new approaches to daily site reporting have the potential to provide a gateway to effective updating and knowledge capture. In this section, we sketch out an approach to automated daily site reporting which can satisfy a number of management functions. It is noted that this approach is directed at the next generation of superintendents, not the current one.

Automated daily site reporting is defined here as the entry of daily performance information at the site through a standardized, interactive computer based report system which is interfaced directly or indirectly with a computer based project management information system. A hard copy report, much like the current daily site report would be generated at site for signing and filing. Information entered would also be used to maintain currency of the schedule, provide a basis for variance analysis and provide knowledge for use on future projects.

Input would be ordered as follows:

1) Project level information: weather data, manpower data, equipment data, general site conditions, etc.



P100

DAILY JOB DIARY & PROGRESS REPORT

Project: Swan Hills Hospital

Project Number: E | | F | M | 0 | 1 | 7

MO	DD	YR
06	07	

Accidents ☐ (See Below) **DAY:** Thursday

Weather: Sunny and Warm **High** 25 °F °C **Low** 21 °F °C

Rain/Snow: ______ MM IN **Wind:** ______ MPH KPH

Visitors: None

Site Working Conditions: ☒ Good ☐ Bad ☐ Unusual (See Below)

Unusual Developments: *(Problems, shortages, delays, etc.)* These developments may cause a delay in your work schedule and increase the cost of completing our work.* The development which occurred may not seem unusual to you, but ask yourself, would it be unusual to an outsider.

Work Area & Progress Today:

Note work which is presently in progress. Use a second page if you require more space or additional pages.

* Do not allow the space provided to limit your report.

Understandings with owners, architects, engineers, inspectors, sub-contractors:

Agreements reached are to be documented as these may have a future affect on your work schedule or quality of work performed.

Other pertinent information:

Each page of your Daily Job Diary is to be signed. This historical account of your project has * no value without your signature.

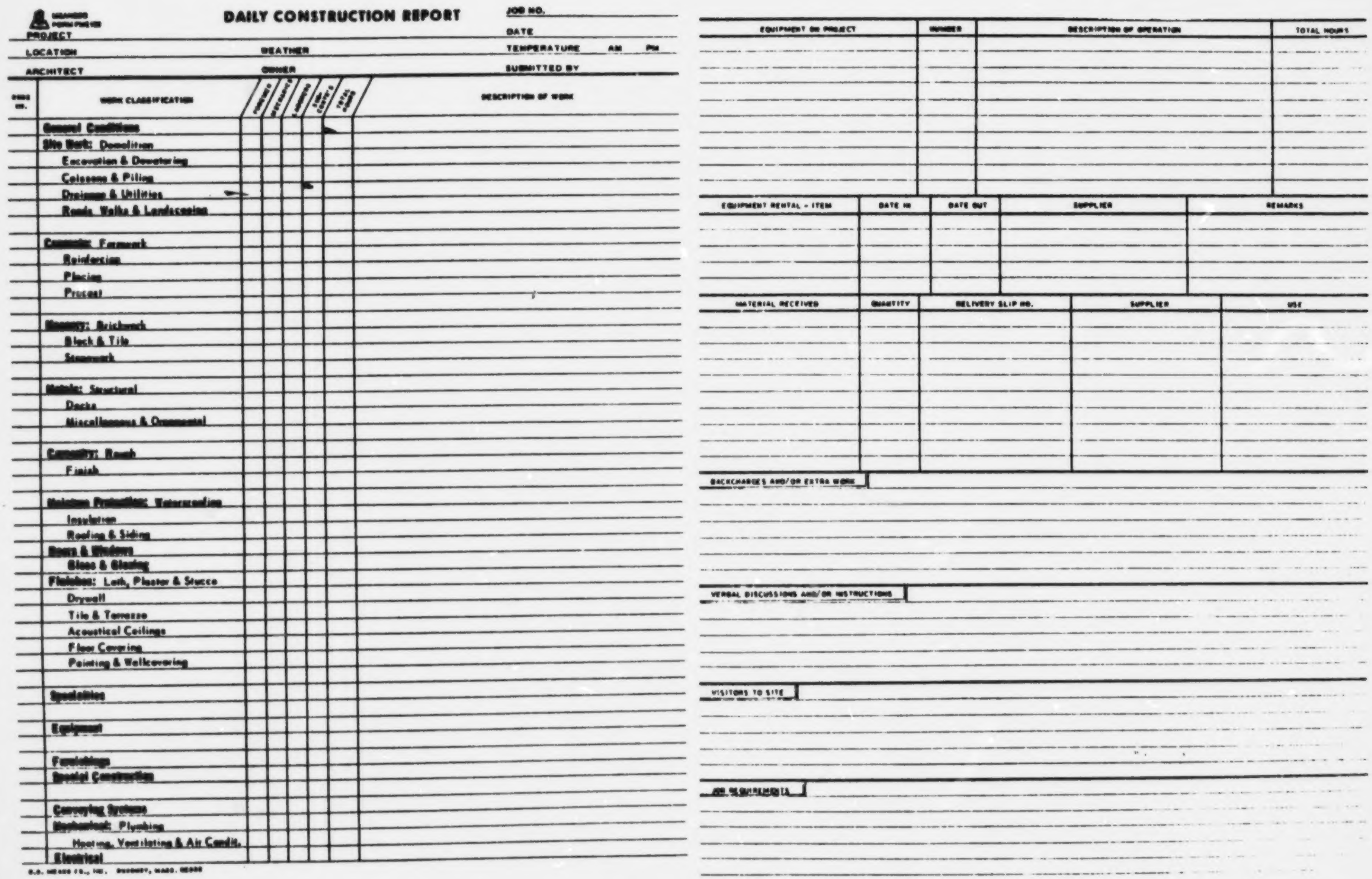
OWN FORCES	No. OF MEN SUPER	No. OF MEN OTHER
Superintendents	1	
Engineers		1
Office Staff		
First Aid		
General Foreman	1	
Carpenters		8
Cement Finishers		3
Crane Operators		
Laborers	1	5
Subtotal	3	17
SUBCONTRACTORS		
Excavation		
P[illegible]		
Re[illegible]ing Steel	1	2
Masonry	1	6
Drywall	1	8
Plaster		
Acoustic Tile		
Structural Steel	1	2
Misc. Iron		
Precast Concrete		
Windows		
Painting		
Ceramic Tile		
Resilient Flooring		
Roofing	1	6
Electrical	1	4
Mechanical	1	3
Elevators		
TOTAL	10	48

- 2 -

______ Superintendent

⑥

Figure 3-4 Simplified Daily Site Report Format



DAILY CONSTRUCTION REPORT

PROJECT
JOB NO.
DATE
LOCATION
WEATHER
TEMPERATURE AM PM
ARCHITECT
OWNER
SUBMITTED BY

PAGE NO.	WORK CLASSIFICATION	[illegible]	[illegible]	[illegible]	SUB-CONTR'S	TOTAL HOURS	DESCRIPTION OF WORK
	General Conditions						
	Site Work: Demolition						
	Excavation & Dewatering						
	Caissons & Piling						
	Drainage & Utilities						
	Roads, Walks & Landscaping						
	Concrete: Formwork						
	Reinforcing						
	Placing						
	Precast						
	Masonry: Brickwork						
	Block & Tile						
	Stonework						
	Metals: Structural						
	Decks						
	Miscellaneous & Ornamental						
	Carpentry: Rough						
	Finish						
	Moisture Protection: Waterproofing						
	Insulation						
	Roofing & Siding						
	Doors & Windows						
	Glass & Glazing						
	Finishes: Lath, Plaster & Stucco						
	Drywall						
	Tile & Terrazzo						
	Acoustical Ceilings						
	Floor Covering						
	Painting & Wallcovering						
	Specialties						
	Equipment						
	Furnishings						
	Special Construction						
	Conveying Systems						
	Mechanical: Plumbing						
	Heating, Ventilating & Air Condit.						
	Electrical						

R.S. MEANS CO., INC. DUXBURY, MASS. [illegible]

EQUIPMENT ON PROJECT	NUMBER	DESCRIPTION OF OPERATION	TOTAL HOURS

EQUIPMENT RENTAL - ITEM	DATE IN	DATE OUT	SUPPLIER	REMARKS

MATERIAL RECEIVED	QUANTITY	DELIVERY SLIP NO.	SUPPLIER	USE

BACKCHARGES AND/OR EXTRA WORK

VERBAL DISCUSSIONS AND/OR INSTRUCTIONS

VISITORS TO SITE

JOB REQUIREMENTS

Figure 3-5 Detailed Daily Site Reporting Format

2) Against a backdrop of the schedule on the screen, either in the form of the work location schedule (figure 3.1) or the field update format (figure 3.2), the status of each activity would be recorded (started, in progress, interrupted, completed). If formal updating of the schedule is being conducted, additional information sought would be forecast completion date for activities in progress and revised schedule start dates for upcoming activities.

3) As the status of each activity is entered, additional activity information could be entered through the use of pull down menus which list standard categories of problems dealing with delays, increased costs, deficiencies, changes, etc.

A basic concept behind the entire system is to have the user make choices, as opposed to writing free form comments or essays. This permits the speedy input of information and allows automated analysis of the input.

Management functions that such a system would support include time control, cost control, quality control, subcontractor control, variance analysis, claims preparation, assessment of site management effectiveness, and change order control.

Preliminary work has been conducted on designing and testing such a system. To date, emphasis has been placed on identifying the minimal data set that should be captured, on developing standard lists of problem causes, and on determining appropriate analysis and data representation schema.

Daily performance data have been collected for over a month for an eleven story condominium project currently under construction in order to demonstrate the kind of information that can be extracted from analyzing daily site information recorded in standardized formats. Of special interest is time series and frequency information. Activity information was captured on the field update form (figure 3.2) by discussing progress with the site superintendent every day.

A database was create in which all data recorded was entered. Results are shown in figures 3.7 through 3.10 for the analysis schema explored to date.

Figures 3.7a through 3.7h summarize general project information and its variation over time. This information is of importance to variance analysis and seeking project duration extensions, etc. Information shown deals with ground conditions (important for substructure level activities), storage on site, site access, weather in terms of precipitation and temperature ranges, manpower usage by trade (general contractor resources shown), worker skill levels and equipment on site. Much of this context information is important in explaining reasons for productivity levels measured. Further investigation is required to determine quantitative links between site conditions and individual activity performance.

Figures 3.8a, b and c provide status information on individual activities which can be used for schedule updating and determination of actual durations and the extent that an activity is interrupted. Note that on the activity problem summary report (figure 3.8b), estimates of delay time and man-hours lost are included. Such information is important for backcharges. The pattern of work on an activity in terms of continuity is shown in figure 3.8c.

Reasons for significant levels of interruption are important to determine quickly. It is possible that interruptions exist because an activity is acting as a buffer for maintaining work continuity for a crew. However, it often means that production rates of activities have not been well balanced or design information, materials or equipment are not available, signalling possible management problems.

An analysis of the frequency of occurrence of different problem types is presented in figure 3.9. Such information is of vital performance to management so that it can focus resources on controllable problems, seek compensation for problems created by others, and devise strategies to work around uncontrollable problems. Once daily site information is computerized, such analysis is readily done. Currently, it is only done when claims arise, and then information, if recorded at all, is not described under standard headings.

Figures 3.10a through c demonstrate additional information that can be generated if recurring problems are suspected with such things as drawings, manpower, or material deliveries.

Normally, unless one was experiencing difficulties on a job site, the number of reports illustrated here would not be generated. The important point is, however, that a mechanism now exists for analyzing sources of difficulty. In addition, schedule updating exclusive of revisions can be automated, and finally, performance information about subtrades, suppliers, designers and even clients is available for use on future projects.

Much work remains to be done to complete development of the concept and validate its usefulness and acceptability in the construction process. It does appear, however, to provide a useful approach to updating and variance analysis.

3.5 SUMMARY

The problem of schedule updating has been explored in depth, with particular emphasis on the problems associated with obtaining as-built schedule information from the field. These problems are important to resolve because of the significant benefits that can arise from having the schedule lead the project and not vice versa. These benefits include speedy response to unanticipated problems, the ability to compensate for delays and the potential to meet or beat schedule deadlines, thereby enhancing profitability and marketability of the firm's services.

It is possible to design reporting formats that are of direct use to site personnel in their day-to-day management tasks and which provide a useful format for recording as-built schedule information. However, they are unwilling to make use of such formats, even when senior management requests their use. Thus one is faced with an organizational/attitudinal problem that is prevalent throughout the industry and which arises in large part from the separation of the site from head office and the traditional autonomy enjoyed by site management. A prerequisite to dealing with this problem is a commitment by senior management to no longer to accept it as inevitable, but rather to address it, mostly through training and hiring policies, and possibly through motivation schemes, including assignment of additional personnel resources at least on larger projects.

Prospects of technical improvements through concepts such as automated daily site reporting appear promising, although much work remains to be done. A key to technical improvements is to make use of reporting that already exists at the site. In this regard, investigation of all essential reporting and how it may be used to serve multiple purposes (e.g. payroll, cost accounting, productivity analysis, schedule updating, knowledge acquisition) would be a fruitful line of inquiry. Finally, the practicality of having subtrades perform some of the reporting required for updating should be investigated. Clearly, it is easy to provide each subtrade with its own short cycle schedule. With some incentive, they will probably record actual performance and submit it back to the general. Questions to be answered are what incentive is required and what confidence can the general contractor place in the information provided.

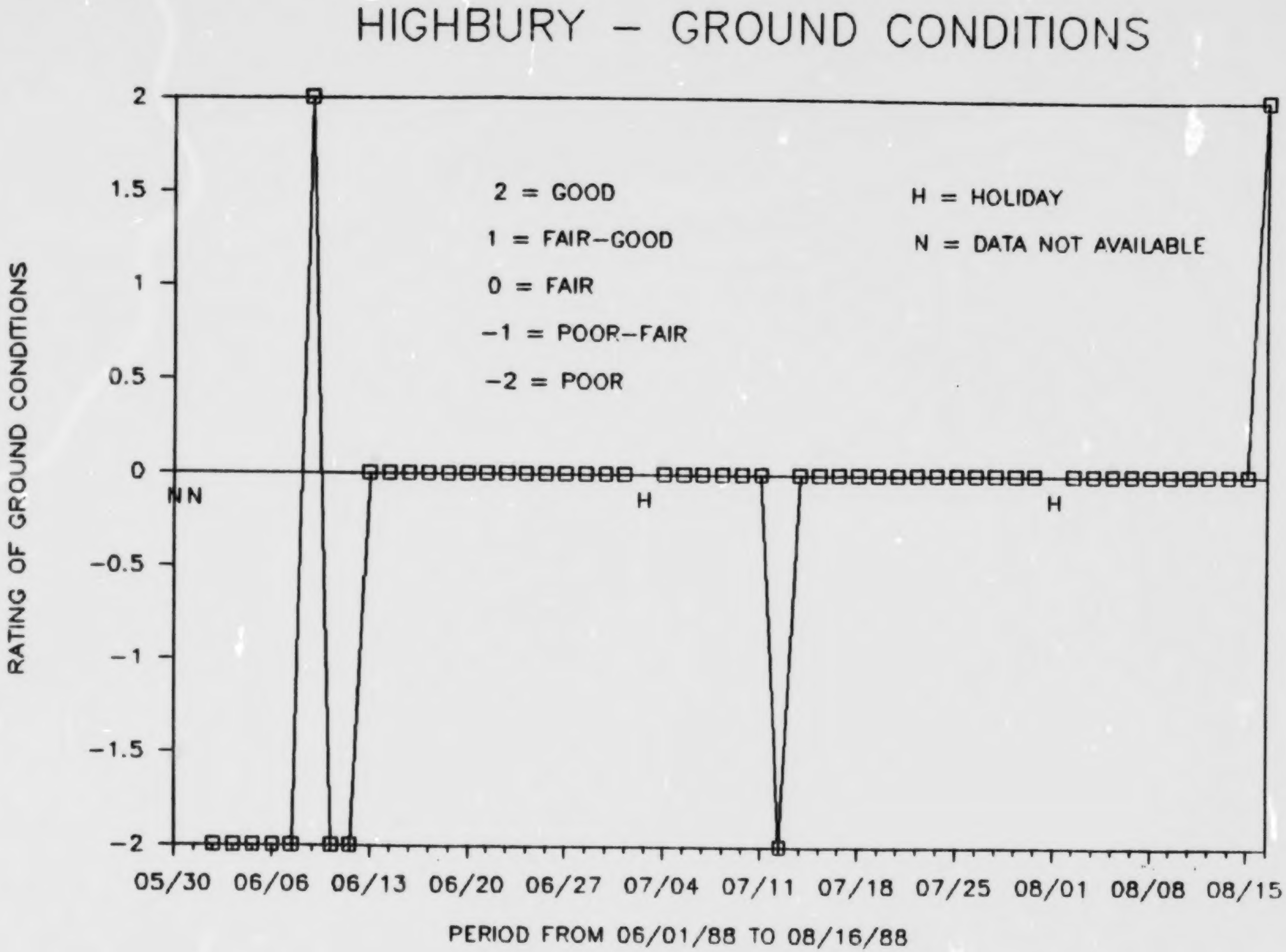


Figure 3-7a Ground Conditions Vs Time

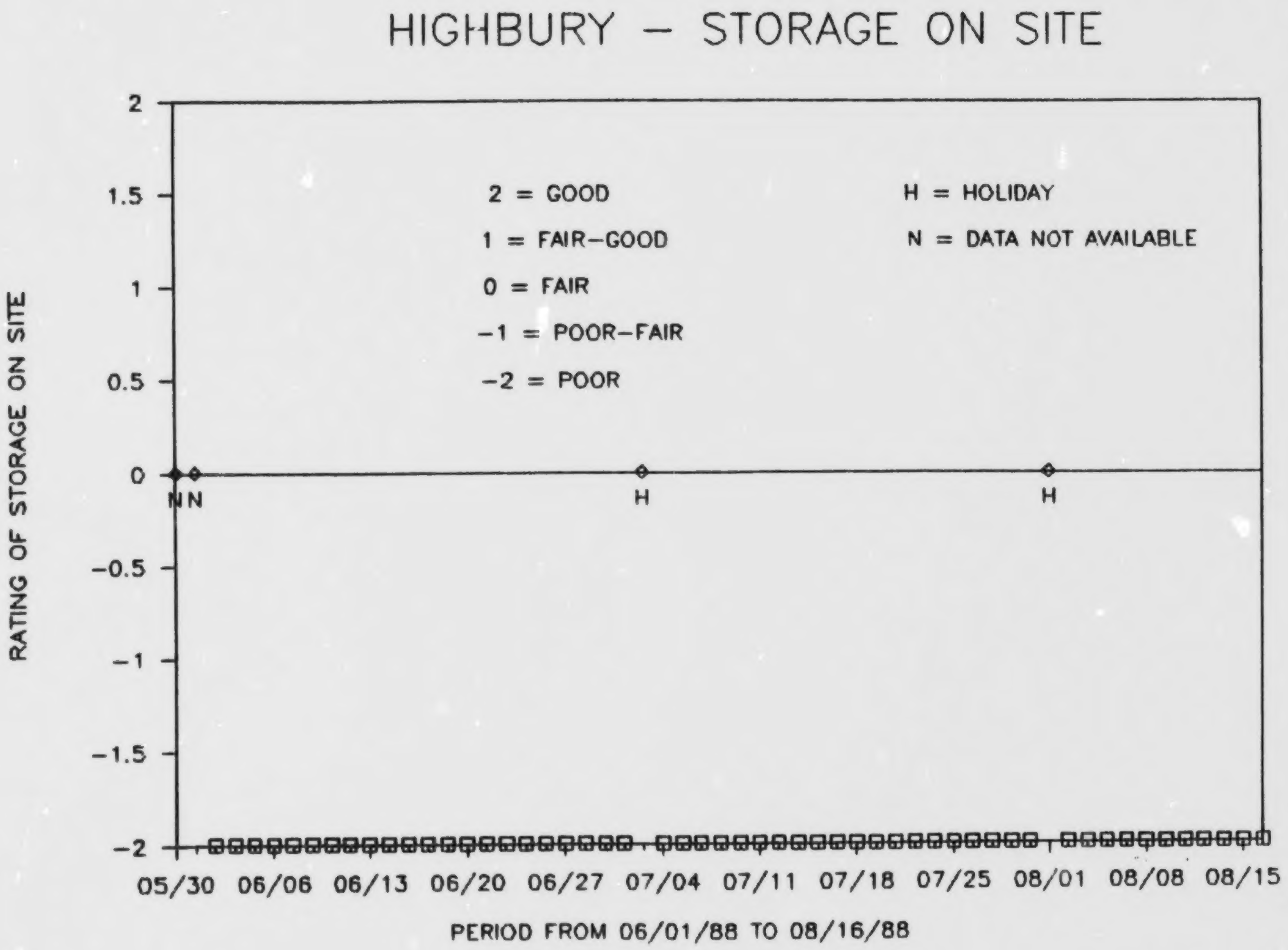


Figure 3-7b Storage on Site Vs Time

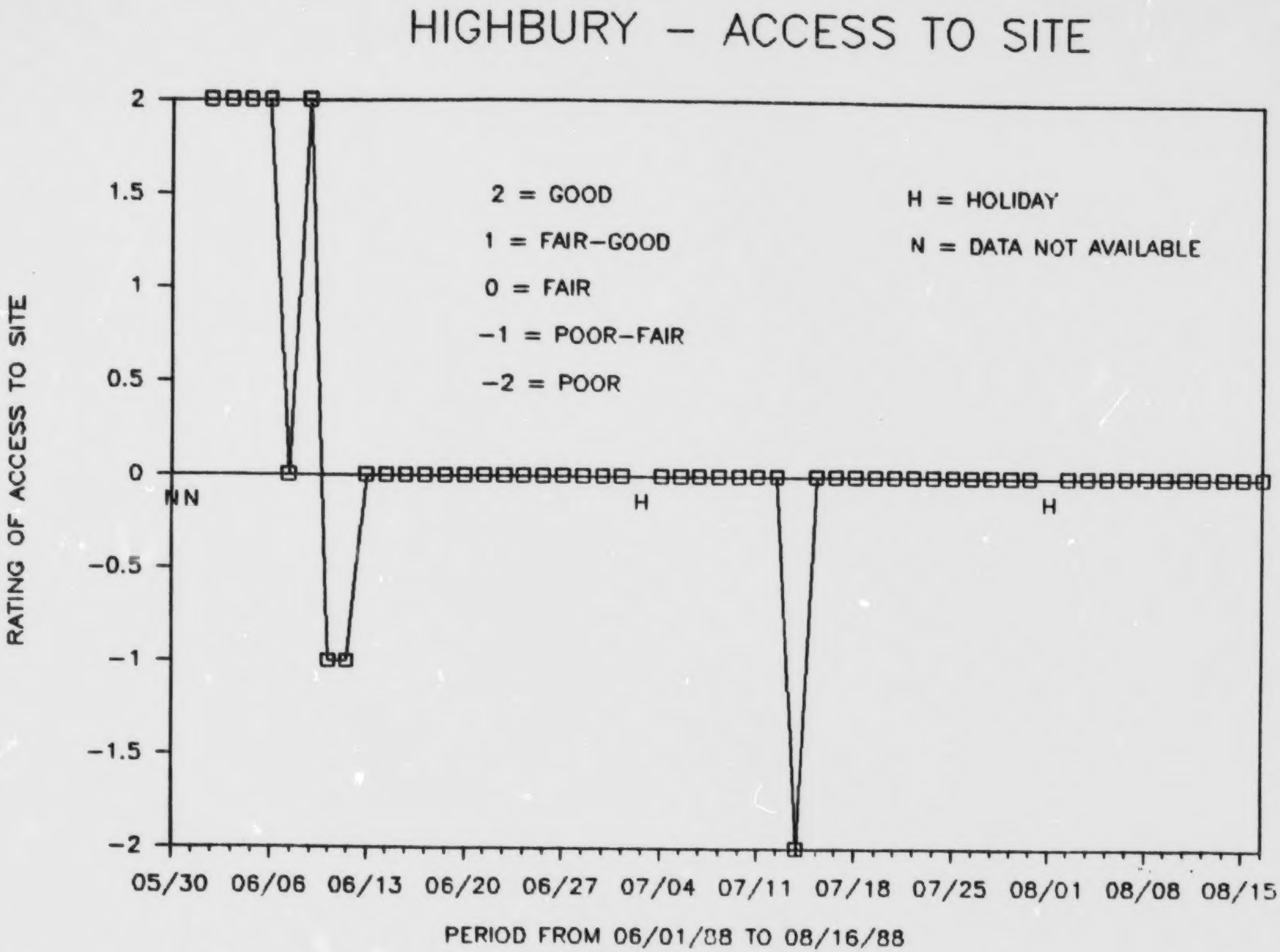


Figure 3-7c Access to Site Vs Time

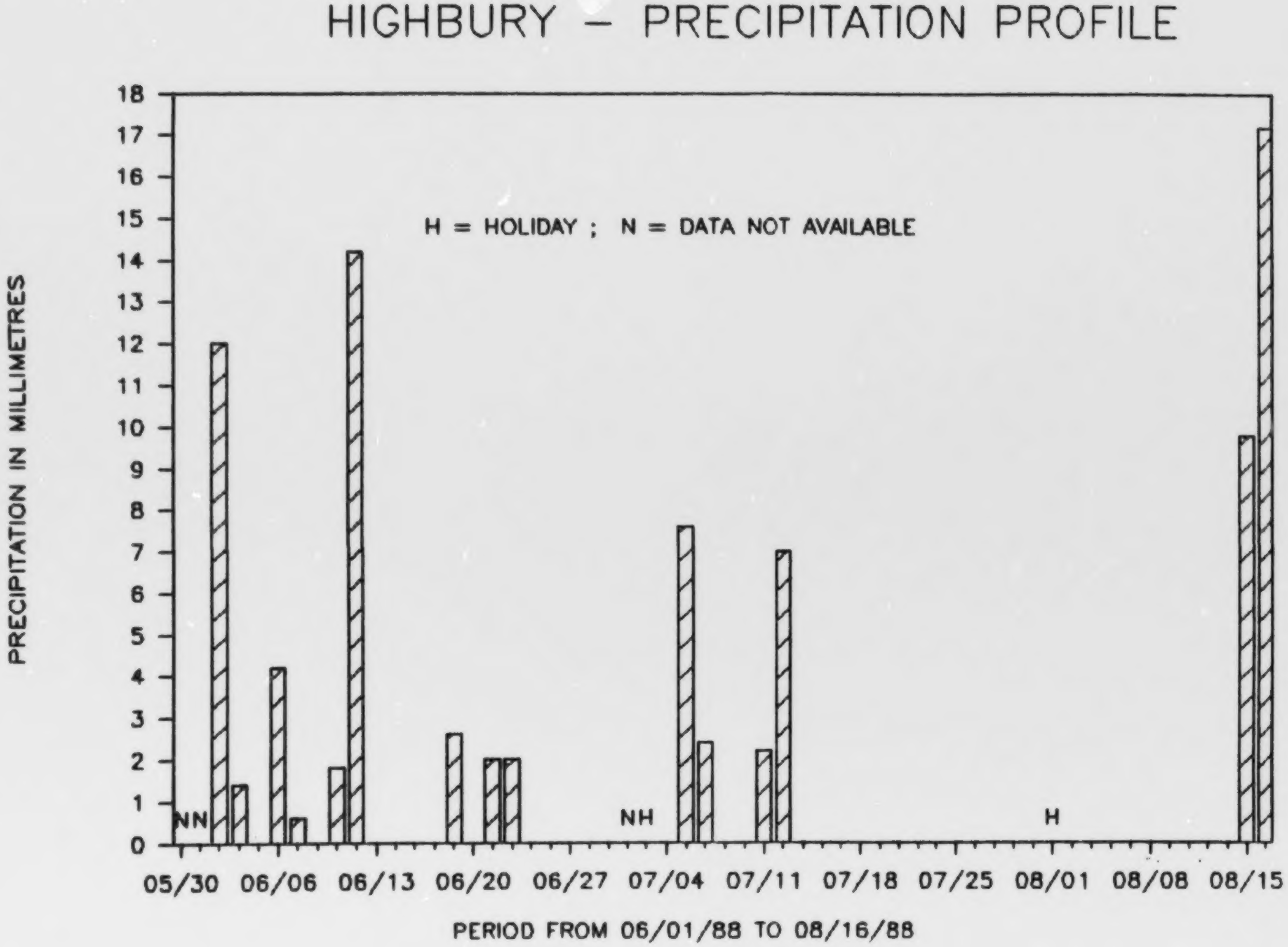


Figure 3-7d Precipitation Vs Time

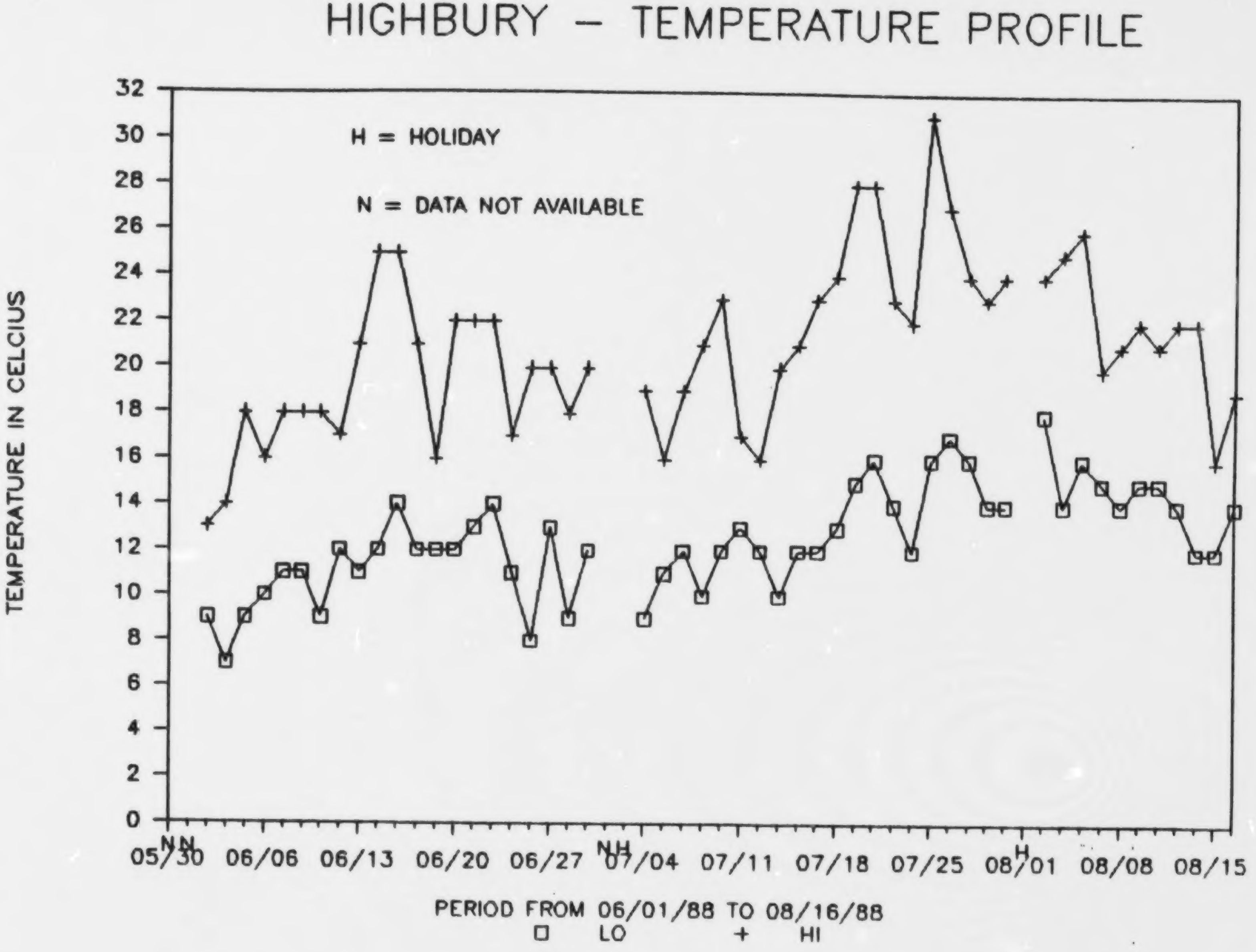


Figure 3-7e Temperature Range Vs Time

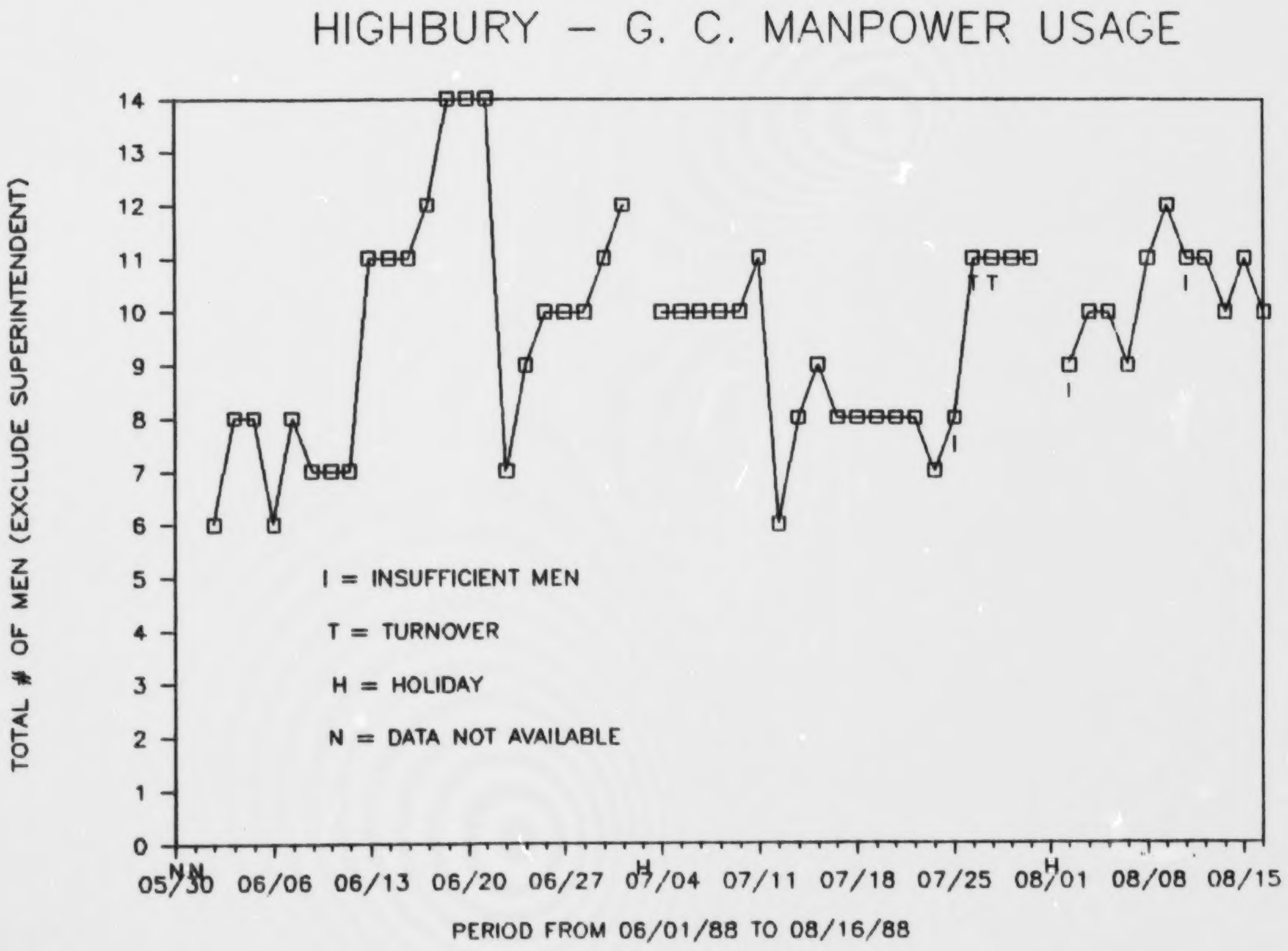


Figure 3-7f G.C. Manpower Vs Time

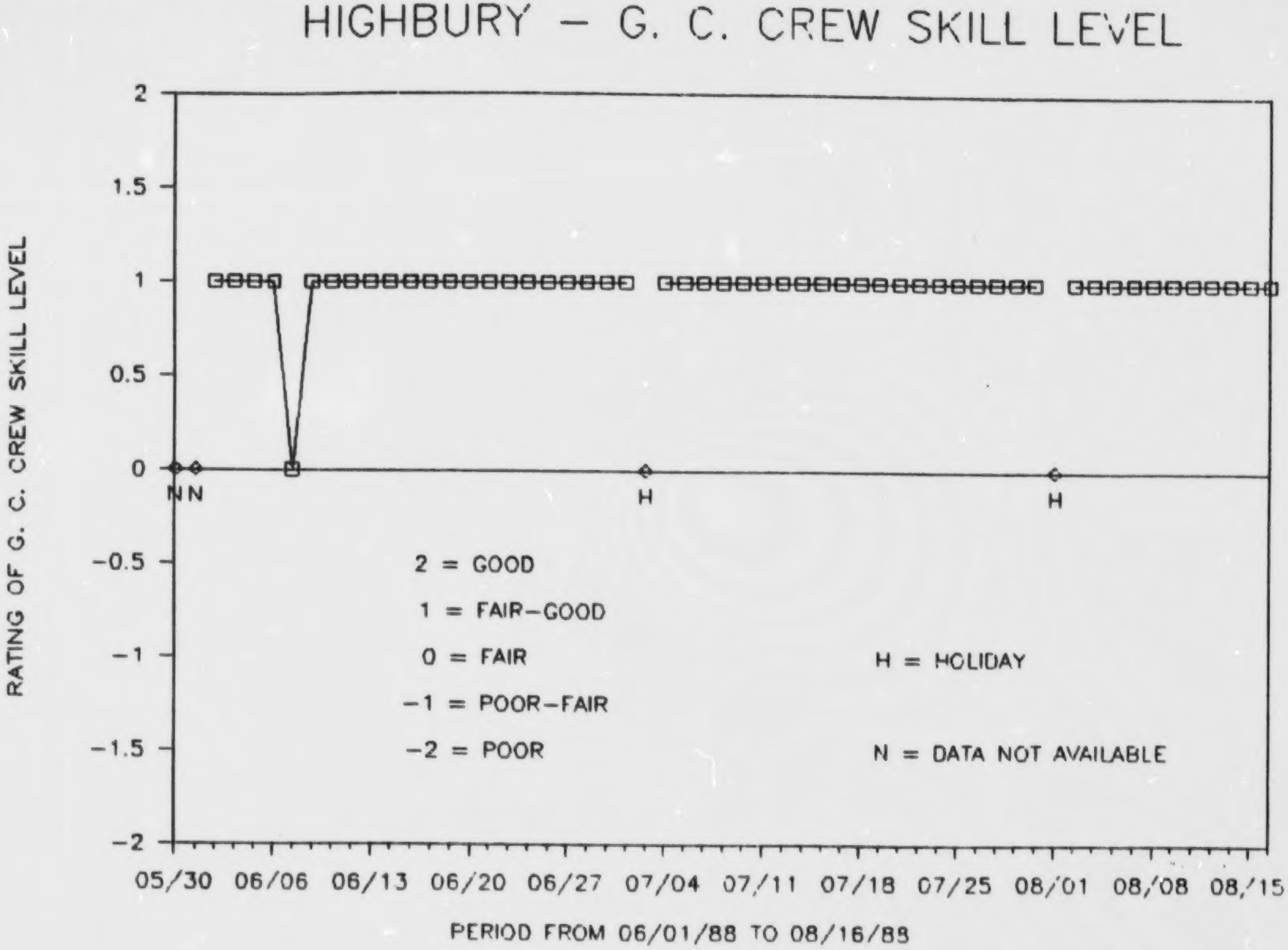


Figure 3-7g G.C. Manpower Skill Level Vs Time

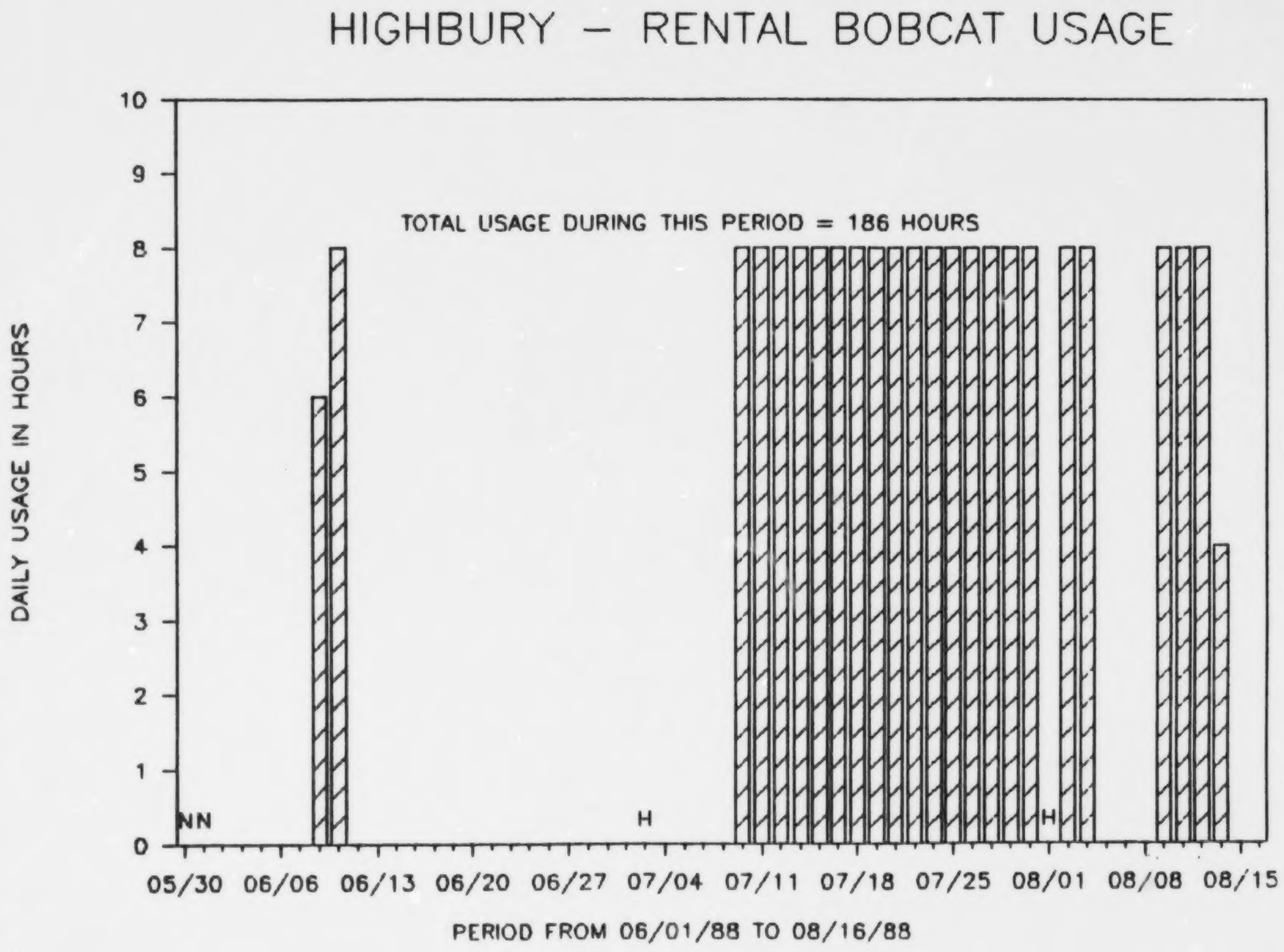
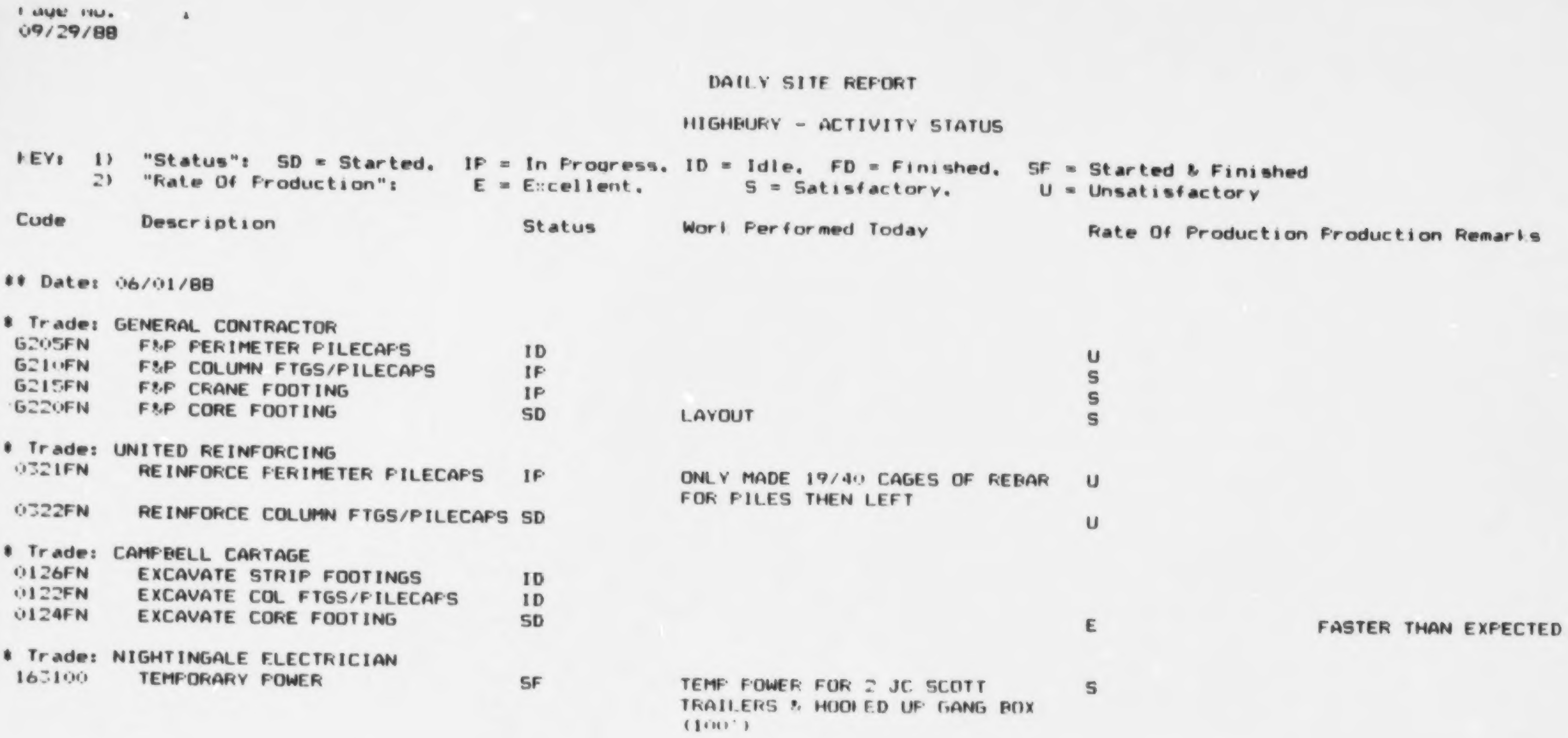


Figure 3-7h Equipment Usage Vs Time



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09/29/88

                                             DAILY SITE REPORT

                                         HIGHBURY - ACTIVITY STATUS

KEY:  1)  "Status":  SD = Started.  IP = In Progress. ID = Idle.  FD = Finished.  SF = Started & Finished
      2)  "Rate Of Production":      E = Excellent.       S = Satisfactory.      U = Unsatisfactory

Code       Description                       Status     Work Performed Today            Rate Of Production Production Remarks

** Date: 06/01/88

* Trade: GENERAL CONTRACTOR
 G205FN     F&P PERIMETER PILECAPS            ID                                         U
 G210FN     F&P COLUMN FTGS/PILECAPS          IP                                         S
 G215FN     F&P CRANE FOOTING                 IP                                         S
 G220FN     F&P CORE FOOTING                  SD         LAYOUT                          S

* Trade: UNITED REINFORCING
 0321FN     REINFORCE PERIMETER PILECAPS      IP         ONLY MADE 19/40 CAGES OF REBAR  U
                                                         FOR PILES THEN LEFT
 0322FN     REINFORCE COLUMN FTGS/PILECAPS SD
                                                                                         U
* Trade: CAMPBELL CARTAGE
 0126FN     EXCAVATE STRIP FOOTINGS           ID
 0122FN     EXCAVATE COL FTGS/PILECAPS        ID
 0124FN     EXCAVATE CORE FOOTING             SD                                         E                    FASTER THAN EXPECTED

* Trade: NIGHTINGALE ELECTRICIAN
 163100     TEMPORARY POWER                   SF         TEMP POWER FOR 2 JC SCOTT       S
                                                         TRAILERS & HOOKED UP GANG BOX
                                                         (100')
```

Figure 3-8a Daily Activity Status Report

```
09/29/88

                                          SUMMARY REPORT

                                  HIGHBURY - ACTIVITY PROBLEMS

Activity  Activity                       Problem                        Problem                               Estimated Estimated
Code      Description                    Type                           Description                             Delay To  Man-Hrs.
                                                                                                              Act.(Hrs.)      Lost


** Date: 06/01/88

* Trade: GENERAL CONTRACTOR
 G205FN    F&P PERIMETER PILECAPS        REWORK DUE TO FIELD ERROR OR   MUST REDESIGN 2 FTGS DUE TO                 0.00      0.00
                                         DAMAGE                         GERHARD'S ERROR DURING PILING
* Subsubtotal *
                                                                                                                  0.00      0.00

* Trade: UNITED REINFORCING
 0321FN    REINFORCE PERIMETER PILECAPS  UNEXPLAINED OR UNNECESSARY     CREW TOOK OFF @ 10:00AM W/O                 0.00      0.00
                                         MOVE                           INFORMING SUPERINTENDENT
 0322FN    REINFORCE COLUMN FTGS/PILECAPS UNEXPALINED OR UNNECESSARY    CREW TOOK OFF @ 10:00AM W/O                 0.00      0.00
                                         MOVE                           INFORMING SUPERINTENDENT
* Subsubtotal *
                                                                                                                  0.00      0.00
** Subtotal **
                                                                                                                  0.00      0.00

** Date: 06/03/88

* Trade: GENERAL CONTRACTOR
 G215FN    F&P CRANE FOOTING             DELAYS DUE TO WAITING FOR      SLIGHTLY LATE ARRIVAL OF                    0.00      0.00
                                         MATERIALS: WAREHOUSE/VENDOR    CONCRETE BUT SCHEDULE NOT
                                                                        THROWN OFF
 G215FN    F&P CRANE FOOTING             DELAYS DUE TO WAITING FOR      REBAR CREW LATE                             4.00      0.00
                                         OTHER CREWS                     NEED PUMP FOR WHOLE DAY
                                                                        INSTEAD OF HALF DAY
* Subsubtotal *
                                                                                                                  4.00      0.00

* Trade: UNITED REINFORCING
 0321FN    REINFORCE PERIMETER PILECAPS  DELAYS DUE TO WAITING FOR      NOT ENOUGH MEN TO HAVE FTGS                 4.00      0.00
                                         FELLOW CREW MEMBERS            READY FOR POUR IN THE MORNING
 0322FN    REINFORCE COLUMN FTGS/PILECAPS DELAYS DUE TO WAITING FOR     NO STEEL                                    4.00      0.00
                                         MATERIALS: WAREHOUSE/VENDOR
 0323FN    REINFORCE CRANE FTG/ANCH BOLTS DELAYS DUE TO WAITING FOR     NOT ENOUGH MEN TO HAVE FTG                  0.00      0.00
                                         FELLOW CREW MEMBERS            READY FOR POUR IN THE MORNING
* Subsubtotal *
                                                                                                                  8.00      0.00

* Trade: CAMPBELL CARTAGE
 0124FN    EXCAVATE CORE FOOTING         MANDATORY CHANGE ORDERS/EXTRA  ENCOUNTERED ROCK                            8.00      0.00
                                         WORK                            CALLED IN BLASTER (1 MAN)
```

Figure 3-8b Activity Problems Vs Time

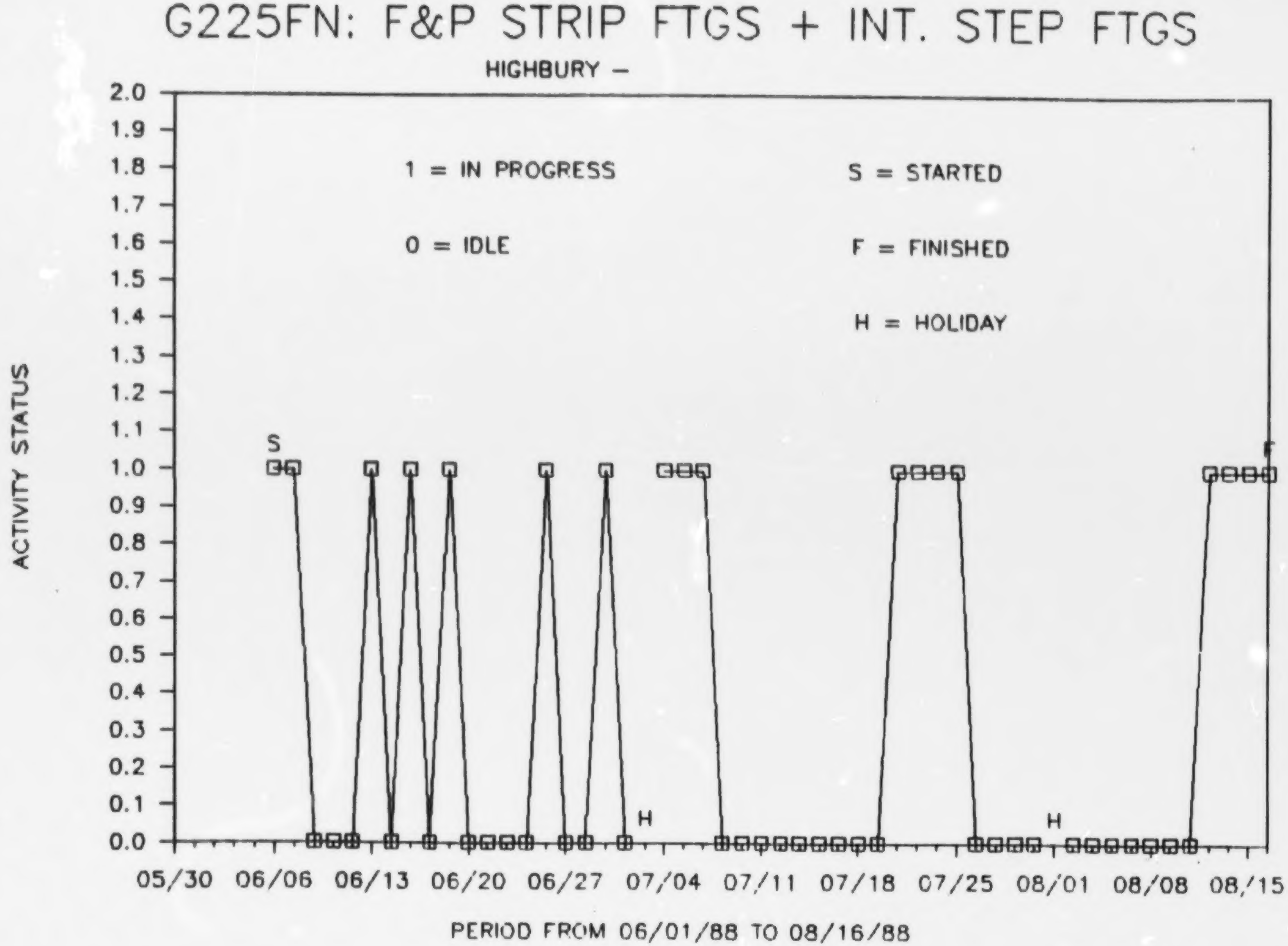

Figure 3-8c Work Pattern for Activity G225FN

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Page No.      1
09/30/88

                                        SUMMARY REPORT

                          HIGHBURY - ACTIVITY PROBLEMS: FREQUENCY OF OCCURRENCE

                                                                                      Est'd Delay Estimated
                                   Activity  Activity                Problem           To Activity  Man-Hrs.
Date      Trade                    Code      Description             Description           (Hrs.)      Lost

** Problem Type: DELAYS DUE TO WAITING FOR FELLOW CREW MEMBERS
 06/03/88 UNITED REINFORCING      0321FN    REINFORCE PERIMETER PILECAPS   NOT ENOUGH MEN TO HAVE FTGS          4.00      0.00
                                                                         READY FOR POUR IN THE MORNING
 06/03/88 UNITED REINFORCING      0323FN    REINFORCE CRANE FTG/ANCH BOLTS NOT ENOUGH MEN TO HAVE FTG           0.00      0.00
                                                                         READY FOR POUR IN THE MORNING
 07/07/88 THRORY WATERPROOFING 1921PK      WATERPROOFING CORE             NOT ENOUGH MEN, BUT NOT              0.00      0.00
                                                                         HOLDING UP ANYTHING AT THIS
                                                                         STAGE
 08/02/88 UNITED REINFORCING                REINFORCE CORE WALLS + WING    NOT ENOUGH MEN: COULD'VE            16.00      0.00
                                            WALLS: PKDE                   POURED CORE & WING WALLS THIS
                                                                         FRIDAY
** Subtotal **
                                                                                                       20.00      0.00

** Problem Type: DELAYS DUE TO WAITING FOR INFORMATION/DECISIONS
 06/07/88 GENERAL CONTRACTOR      G225FN    F&P STRIP FOOTINGS             COMMON WALL ELEVATIONS NOT           8.00      0.00
                                                                         AVAILABLE FROM STRUCTURAL
 06/29/88 GENERAL CONTRACTOR      G302PK    F&P EXT WALLS/COLS: PARKADE    NO INFO FOR STEEL CHANGES TO        16.00      0.00
                                                                         LOWER ELEVATION OF LINE 15
                                                                         WALL
 08/04/88 GENERAL CONTRACTOR      G225FN    F&P STRIP FOOTINGS + INT. STEP ACTIVITY IDLE BECAUSE WAITING        0.00      0.00
                                            FTGS.                         FOR SOILS REPORT
** Subtotal **
                                                                                                       24.00      0.00

** Problem Type: DELAYS DUE TO WAITING FOR MATERIALS: WAREHOUSE/VENDOR
 06/03/88 GENERAL CONTRACTOR      G215FN    F&P CRANE FOOTING              SLIGHTLY LATE ARRIVAL OF             0.00      0.00
                                                                         CONCRETE BUT SCHEDULE NOT
                                                                         THROWN OFF
 06/03/88 UNITED REINFORCING      0322FN    REINFORCE COLUMN FTGS/PILECAPS NO STEEL                             4.00      0.00
 07/26/88 GENERAL CONTRACTOR      G302PK    F&P EXT WALLS/COLS: PARKADE +  REMPEL LATE WITH CONCRETE            1.75      0.00
                                            INT. WALLS                     DELIVERY
 08/03/88 UNITED REINFORCING                REINFORCE SLAB ON GRADE        CANWEST LATE WITH MESH               6.00      0.00
                                                                         DELIVERY FOR S.O.G.
 08/11/88 GENERAL CONTRACTOR                F&P CORE WALLS + WING WALLS:   REMPEL LATE WITH CONCRETE            1.50      0.00
                                            PKDE                           DELIVERY
** Subtotal **
                                                                                                       13.25      0.00

** Problem Type: DELAYS DUE TO WAITING FOR OTHER CREWS
 06/03/88 GENERAL CONTRACTOR      G215FN    F&P CRANE FOOTING              REBAR CREW LATE                      4.00      0.00
                                                                          NEED PUMP FOR WHOLE DAY
                                                                         INSTEAD OF HALF DAY
```

Figure 3-9 Classification of Activity Problems and Frequency of Occurrence

```
Page No.      2
09/30/88

                                SUMMARY REPORT

                HIGHBURY - ACTIVITY PROBLEMS: FREQUENCY OF OCCURRENCE

                              Activity  Activity                               Problem                              Est'd Delay Estimated
Date      Trade               Code      Description                            Description                          To Activity  Man-Hrs.
                                                                                                                       (Hrs.)       Lost
** Subtotal **

                                                                                                                        4.00        0.00
** Problem Type: EQUIPMENT BREAK DOWN
 06/09/88 GENERAL CONTRACTOR   G303PK   BACKFILL/GRADING                     BOBCAT GOT STUCK IN CLAY                  2.00        0.00
 06/15/88 GENERAL CONTRACTOR   G302PK   F&P EXT WALLS/COLS: PARKADE          LINE PUMP KEPT GETTING CLOGGED            0.00        0.00
** Subtotal **                                                               BY LARGE AGG. ALL DAY LONG

                                                                                                                        2.00        0.00
** Problem Type: MANDATORY CHANGE ORDERS/EXTRA WORK
 06/03/88 CAMPBELL CARTAGE     0124FN   EXCAVATE CORE FOOTING                ENCOUNTERED ROCK                          8.00        0.00
                                                                              CALLED IN BLASTER (1 MAN)
 08/04/88 UNITED REINFORCING            REINFORCE CORE WALLS + WING          PROBLEM WITH DESIGN OF REBAR              4.00        0.00
                                        WALLS: PKDE                          HOOKS, DIFFICULT TO PLACE
** Subtotal **                                                               STEEL

                                                                                                                       12.00        0.00
** Problem Type: OTHERS
 06/23/88 GENERAL CONTRACTOR   G302PK   F&P EXT WALLS/COLS: PARKADE          MUST USE CRANE & BUCKETS FOR              0.00        0.00
                                                                             CONCRETE POURING (TAKES
                                                                             LONGER)
 07/04/88 THRORY WATERPROOFING 1921PK   WATERPROOFING CORE                   WATER WEEPAGE ON TOP OF FTGS              2.00        0.00
                                                                             HAVE TO BE DRIED OUT FIRST
 07/15/88 GENERAL CONTRACTOR   G303PK   BACKFILL/GRADING                     SOIL A LITTLE TOO WET &                   0.00        0.00
                                                                             COMPACTORS NOT ADEQUATE
 08/10/88 GENERAL CONTRACTOR            F&P CORE WALLS + WING WALLS:         SHOULD HAVE HAD MORE LABOUR               0.00        0.00
                                        PKDE                                 MONEY IN IT, BUT TIGHT IN
                                                                             SPACE
 08/16/88 GENERAL CONTRACTOR   G304PK   F&P SLAB ON GRADE                    DIFFICULT DETAILS FOR                     0.00        0.00
** Subtotal **                                                               BULKHEADS

                                                                                                                        2.00        0.00
** Problem Type: REWORK DUE TO FIELD ERROR OR DAMAGE
 06/01/88 GENERAL CONTRACTOR   G205FN   F&P PERIMETER PILECAPS               MUST REDESIGN 2 FTGS DUE TO               0.00        0.00
                                                                             GERHARD'S ERROR DURING PILING
 07/14/88 GENERAL CONTRACTOR   G309FN   DRAIN TILE, U/G PLUMBING             RELAY MECH DRAINAGE BETWEEN               0.00        0.00
                                                                             MAIN CATCH BASIN & PUMP SUMP
 08/02/88 GENERAL CONTRACTOR   G202FN   EXCAV. DRAIN TILES, U/G PLUMB.       REDUG UP CLAIRMONT'S WATERMAIN            1.00        0.00
** Subtotal **                                                               DUE TO FAILED TEST - BACKCHARG

                                                                                                                        1.00        0.00
```

Figure 3-9 (Cont'd) Classification of Activity Problems and Frequency of Occurrence

```
Page No.      3
09/30/88

                                        SUMMARY REPORT

                    HIGHBURY - ACTIVITY PROBLEMS: FREQUENCY OF OCCURRENCE

                                                                                   Est'd Delay Estimated
                             Activity  Activity                  Problem           To Activity  Man-Hrs.
Date      Trade              Code      Description               Description           (Hrs.)      Lost

** Problem Type: UNEXPLAINED OR UNNECESSARY MOVE
06/01/88 UNITED REINFORCING  0321FN    REINFORCE PERIMETER PILECAPS   CREW TOOK OFF @ 10:00AM W/O     0.00     0.00
                                                                 INFORMING SUPERINTENDENT
06/01/88 UNITED REINFORCING  0322FN    REINFORCE COLUMN FTGS/PILECAPS CREW TOOK OFF @ 10:00AM W/O     0.00     0.00
                                                                 INFORMING SUPERINTENDENT
** Subtotal **
                                                                                        0.00     0.00

** Problem Type: WEATHER
07/06/88 THRORY WATERPROOFING 1921PK   WATERPROOFING CORE        RAINY WEATHER PERSISTING (1/2   12.00     0.00
                                                                 DAY TODAY & 1 DAY YESTERDAY)
07/08/88 GENERAL CONTRACTOR  G302PK    F&P EXT WALLS/COLS: PARKADE  TOO WARM (NO WIND IN THE HOLE:  1.20     0.00
                                                                 COMMON WALL)
07/12/88 GENERAL CONTRACTOR  G302PK    F&P EXT WALLS/COLS: PARKADE  RAIN                          1.60     0.00
07/12/88 GENERAL CONTRACTOR  G309FN    DRAIN TILE, U/G PLUMBING  RAIN                             1.60     0.00
07/12/88 GENERAL CONTRACTOR  G202FN    EXCAV. DRAIN TILES, U/G PLUMB. RAIN                        1.60     0.00
08/16/88 GENERAL CONTRACTOR  G304PK    F&P SLAB ON GRADE         COULD NOT POUR DUE TO RAIN        8.00     0.00
** Subtotal **
                                                                                       26.00     0.00
*** Total ***
                                                                                      104.25     0.00
```

Figure 3-9 (Cont'd) Classification of Activity Problems and Frequency of Occurrence

```
09/29/88

                                         SUMMARY REPORT

                              HIGHBURY - G. C. DRAWINGS AVAILABILITY

KEY: 1)  "Available?": .T. = Yes,  .F. = No                                                  3) "Detailing": A = Adequate
     2)     "Quality": PP = Poor,  PF = Poor-Fair,  FF = Fair,  FG = Fair-Good,  GG = Good                  I = Inadequate

Date      Available?    Availability Remarks          Quality    Quality Remarks            Detailing Detailing Remarks

06/01/88 .F.            CHASING AFTER NEW DRAWINGS   GG                                     A
                        FOR COMMON WALL
06/02/88 .T.                                         GG                                     A
06/03/88 .T.                                         GG                                     A
06/06/88 .T.                                         GG                                     A
06/07/88 .F.            FOR COMMON WALL (AS NOTED    GG                                     A
                        ON 06/01/88)
06/08/88 .F.            COMMON WALL ELEVATIONS       GG                                     A
                        STILL NOT AVAILABLE
06/09/88 .F.            STRUCTURAL ENG. PROMISED TO  GG                                     A
                        HAVE COMMON WALL INFO. BY
                        TOMORROW
06/10/88 .T.            FINALLY GOT THE ELEVATIONS   GG                                     A
                        FOR THE COMMON WALL
06/13/88 .T.                                         GG                                     A
06/14/88 .T.                                         PP         ELEVATION DRAWINGS (REFER  I         ELEVATIONS: NEED TO KNOW
                                                                TO DETAILING)                        FOR FOUR OF LINE 1 WALL
                                                                                                     TOMORROW
06/15/88 .T.                                         GG                                     A
06/16/88 .T.                                         GG                                     A
06/17/88 .T.                                         GG                                     A
06/20/88 .T.                                         FG                                     A
06/21/88 .T.                                         GG                                     A
06/22/88 .T.                                         GG                                     A
06/23/88 .T.                                         GG                                     A
06/24/88 .T.                                         GG                                     A
06/27/88 .T.                                         GG                                     A
06/28/88 .T.                                         GG                                     A
06/29/88 .F.            GLOTMAN LATE WITH STEEL      GG                                     A
                        CHANGES TO LOWER ELEVATION
                        OF LINE 15 WALL
06/30/88 .T.            RECEIVED STEEL CHANGES       GG                                     A
07/04/88 .T.                                         GG                                     A
07/05/88 .T.                                         GG                                     A
07/06/88 .T.                                         GG                                     A
07/07/88 .T.                                         GG                                     A
07/08/88 .T.                                         GG                                     A
07/11/88 .T.                                         GG                                     A
07/12/88 .T.                                         GG                                     A
07/13/88 .T.                                         GG                                     A
07/14/88 .T.                                         GG                                     A
07/15/88 .T.                                         GG                                     A
07/18/88 .T.                                         GG                                     A
07/19/88 .T.                                         GG                                     A
07/20/88 .T.                                         GG                                     A
```

Figure 3-10a Concrete Deliveries Vs Time

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PAGE NO.
09/29/88

                                              SUMMARY REPORT

                                HIGHBURY - G. C. MANPOWER INFORMATION (SUPPLEMENT)

Date      Work       Work Availability        Crew Skill                Sufficient Men To Meet    Turnover
          Available? Remarks                  Level Remarks             Job Conditions Remarks    Remarks
          (.T.= Yes,
           .F.= No )

06/01/88 .T.                                  3 GOOD & 3 NOT SO GOOD
                                               TRYING TO WEED OUT
06/02/88 .T.                                  STILL HAVE SOME GOOD,
                                              SOME NOT SO GOOD
06/03/88 .T.
06/06/88 .T.                                                            ONE GUY HAD A HEARTATTACK
                                                                        OVER THE WEEKEND
06/07/88 .T.
06/08/88 .T.
06/09/88 .T.
06/10/88 .T.
06/13/88 .T.
06/14/88 .T.
06/15/88 .T.
06/16/88 .T.
06/17/88 .T.
06/20/88 .T.
06/21/88 .T.
06/22/88 .T.                                                            LAID OFF 4 CARPENTERS & 3
                                                                        LABOURERS YESTERDAY
06/23/88 .T.
06/24/88 .T.
06/27/88 .T.
06/28/88 .T.
06/29/88 .T.
06/30/88 .T.
07/04/88 .T.
07/05/88 .T.
07/06/88 .T.
07/07/88 .T.
07/08/88 .T.
07/11/88 .T.
07/12/88 .T.
07/13/88 .T.
07/14/88 .T.
07/15/88 .T.
07/18/88 .T.
07/19/88 .T.
07/20/88 .T.
07/21/88 .T.
07/22/88 .T.
07/25/88 .T.                                                            EXPECTED 2 CARPS FROM
                                                                        2ND&YEW BUT NO SHOW.
                                                                        DEFINITE PROBLEM
07/26/88 .T.                                                            "JUST RIGHT" FOR WHAT     2 NEW CARPS FROM 2ND &
                                                                        BILL NEEDS                YEW
```

Figure 3-10b Manpower Issues Vs Time

09/29/88

SUMMARY REPORT

HIGHBURY - CONCRETE DELIVERY

KEY: 1) "On Time?": .T. = On Time, .F. = Late
2) "Quality" : PP = Poor, PF = Poor-Fair, FF = Fair, FG = Fair-Good, GG = Good

Date	Material	Supplier	On Time?	Quality	Remarks	Quantity Delivered (m3)
06/03/88	CONCRETE	REMPEL	.T.	GG		60.00
06/07/88	CONCRETE	REMPEL	.T.	GG		15.00
06/15/88	35 MPA CONCRETE	REMPEL	.F.	FF	CONCRETE WAS DELIVERED TOO EARLY. AND AGGREGATE SHOULD BE =< 3/4", BUT LARGE AGGREGATES FOUND (APPROX. 4 1/2") WHICH WERE CLOGGING THE LINE OF THE LINE PUMP.	10.00
06/15/88	25 MPA CONCRETE	REMPEL	.T.	FF		14.00
06/23/88	25 MPA CONCRETE	REMPEL	.T.	GG		42.00
06/24/88	20 MPA CONCRETE	REMPEL	.T.	GG		2.00
06/27/88	25 MPA CONCRETE	REMPEL	.T.	GG		30.50
06/29/88	20 MPA CONCRETE (FOR 12 COL. FTGS)	REMPEL	.T.	GG		22.70
06/30/88	25 MPA CONCRETE (FOR PERIMETER WALL)	REMPEL	.T.	GG		20.00
07/04/88	35 MPA CONCRETE (FOR 8 COLUMNS)	LAFARGE	.T.	GG		6.00
07/05/88	35 MPA CONCRETE	REMPEL	.T.	GG		7.60
07/06/88	25 MPA CONCRETE	REMPEL	.T.	GG		9.60
07/06/88	35 MPA CONCRETE	REMPEL	.T.	GG		3.40
07/13/88	35 MPA CONCRETE (FOR 2 COLS)	REMPEL	.T.	GG		1.25
07/13/88	25 MPA CONCRETE (FOR WALLS)	REMPEL	.T.	GG		10.40
07/20/88	25 MPA CONCRETE	REMPEL	.T.	GG		19.40
07/22/88	25 MPA CONCRETE	REMPEL	.T.	GG		5.00
07/25/88	35 MPA CONCRETE (FOR 6 COLS & ELEVATOR MACH RM SLAB)	REMPEL	.T.	GG		6.00
07/26/88	35 MPA CONCRETE (FOR INT. WALL)	REMPEL	.F.	GG	DELIVERY WAS LATE BY 1'45".	13.20
07/27/88	35 MPA CONCRETE	REMPEL	.T.	GG		1.80
08/02/88	25 MPA CONCRETE (FOR CROSSING GRATE)	REMPEL	.T.	GG		2.60
08/04/88	25 MPA "SPECIAL" CONCRETE (FOR S.O.G.)	REMPEL	.T.	GG		77.50
08/04/88	35 MPA CONCRETE (FOR STAIRS)	REMPEL	.T.	GG		2.00
08/05/88	35 MPA CONCRETE (FOR SHEAR WALLS + COLS)	REMPEL	.T.	GG		16.80
08/09/88	35 MPA CONCRETE (FOR INT. WALL JUST SOUTH OF CORE)	REMPEL	.T.	GG		3.60
08/11/88	35 MPA CONCRETE (FOR CORE WALLS)	REMPEL	.T.	GG		36.50
08/16/88	25 MPA CONCRETE (FOR LAST OF STRIP FTGS)	REMPEL	.T.	GG		6.00

Figure 3-10c Drawing Availability Vs Time

CHAPTER 4: REPRESENTING PROJECT EXPERIENCE

4.1 INTRODUCTION

The case has been made in previous chapters about the importance of cataloguing experience from previous projects and representing it in a way that is easily accessible and useful for future ones. The strength of current computer based project management systems lies in their ability to analyze and archive large volumes of data, once a project has been described to the system by the user. But each time the user starts a new project, he starts with an empty system. No help is offered with the most knowledge intensive tasks of identifying activities, checking for their completeness, sequencing them and estimating durations. Once a project is underway, no help save for exception reporting is available for identifying problem sources. In other words, current systems offer little or no assistance in generating and interpreting plans and schedules.

Given that initial formulation of the project schedule is the most time consuming task and that project management resources are scarce, significant benefits could be derived if project management systems included knowledge and/or aids to assist with the front end set-up work. When we refer to knowledge being resident in a project management system, we mean that data/information pertaining to the general problem domain (e.g. scoping and sequencing high-rise residential construction work) is encoded within the system, it can be operated upon along with specific project context information using for example, rules, to deduce other facts (e.g. if brickwork is required on the facade, then scaffolding is required) and that explanations of computer generated decisions or facts can be offered (e.g. temporary heating is required for concrete work because the superstructure will be built in December and January). Ideas on how to represent and include such knowledge provide the focus of this chapter.

Our experience with the firm that participated in this research project gave us some first hand exposure to the benefits that can accrue from embedding experience into a system. In this case, files from previous jobs were copied into a system, and then using a somewhat cumbersome process, the files were tailored to reflect different project size parameters, work packaging and design features. Crude as this approach was, it permitted capture of experience in a reusable format, refinement of this experience as it was transferred from project to project and speedy definition of an initial plan and schedule, such that with one morning's work, a detailed working schedule was available. Use was made of these schedules in negotiating with the owner and subtrades and provided the firm with a professional image and schedule commitments that could reasonably be met.

In tackling this problem, one of two approaches can be taken. The first approach involves more basic research and deals with the application of artificial intelligence and expert systems concepts to generate and interpret automatically project plans and schedules. The goal of this work is to develop an artificial intelligence based system for project management. This approach is being pursued by a number of researchers (references 3, 5-8, 10-14 and 17). The interested reader should refer to references 10 and 11 for a thorough overview of progress to date and for a reasonably complete listing of reference material.

Progress has been made on the automatic generation of activity lists, network formulation, duration estimation, analysis of progress and treatment of uncertainty. Treatment of basic design elements (e.g. a footing, a column, etc) provides the basic building block for this work with upward aggregation of such elements to form project activities. Such an approach is very data intensive and is directed at the time when design and construction are integrated in a computer based process. The development of practical systems that can handle full scale projects is some years away. Further, the sophistication required of the users of such systems plus the hardware requirements are beyond the personnel and financial resource capabilities of most general building contractors and developer-builders. However, many of the findings of this work in terms of knowledge acquisition (reference 4), and knowledge representation in terms of frames and rules are of direct relevance to more pragmatic approaches of incorporating expertise into project management systems.

The second approach views expert systems concepts as one of several tools to be used for storing, accessing and interpreting previous experience in terms of project files, lists and rules for purposes of project scoping, activity sequencing, duration estimation and variance analysis. Thus, one may embed a number of expert systems directed at specific tasks within a larger system for analyzing and archiving project information. The payoff from this approach is that useful procedures can be developed in the short term and practical sized projects can be dealt with. It is noted that this approach assists project personnel in the front-end definition phase, it does not replace them. Work of direct relevance to this approach is described in references 5 and 15.

The problem of partially or fully automating the tasks of activity scoping, sequencing and duration estimation, independent of which of the above two approaches is adopted, is made very difficult because of the scale of building projects, the diversity in their design details and materials, the myriad number of ways work can be packaged and the sheer volume of construction knowledge. Much of the work involved in addressing this problem revolves around coping with the scale of the knowledge base and the vast number of ways its elements can be combined. Decomposition or so called divide and conquer strategies provide much of the focus for approaches to deal with the problem scale.

4.2 OBJECTIVES AND METHODOLOGY

We seek to describe a schema, along with associated issues, directed at developing a computer assisted approach to the initial formulation of a project schedule for high-rise residential construction. The specific focus is on the scoping and sequencing of project level activities and procurement sequences, with secondary treatment of activity duration estimation. Detailed computer implementation issues are not examined. See reference 2 for a comprehensive treatment of such issues.

Our approach to the foregoing involves several steps. First, in section 4.3, we examine various existing frameworks for describing knowledge (e.g. standardized coding systems, description of projects in terms of building systems and phases, etc). Refinements to these frameworks are discussed in terms of how they might be formalized so that planning and scheduling knowledge can be represented and operated upon electronically. The tasks of acquiring and organizing knowledge in each of these frameworks and the role of project personnel in providing expertise are touched upon, as appropriate. Most of these frameworks are directed at decomposing a complex problem and its supporting knowledge base into a set of smaller, more manageable subproblems and knowledge bases. This approach parallels the one used in industry in which various specialties comprise the design team as well as the construction team, each with its own knowledge base.

Then, in section 4.4, we examine further the attributes of an activity introduced in Chapter 3 and how these attributes might be specified through application of the knowledge base.

Finally, in section 4.5 we conclude with a brief description of the basic components of an expert system for scoping and sequencing along with how these components relate to one another.

4.3 INFORMATION AND KNOWLEDGE ORGANIZATION ISSUES

In this section various schema for organizing knowledge and sources of information are explored. These schema do not represent distinctly different approaches. In fact, organizational issues within each schema intersect with one another. Central to the development of a knowledge-based system is the ability to have standardized frameworks for describing project details, phases, activities, etc., while still recognizing the need to handle the significant diversity that exists among projects even within the same class, such as high-rise residential construction. The focus is on approaches that permit treatment of large chunks of knowledge - i.e. we seek to exploit the fact that we are operating within the context of high-rise housing. Inherent within that context are certain activities and relationships that are fundamental to the process and which constitute the core of our knowledge. This core we take as a given and augment it to reflect specific project and market characteristics.

4.3.1 Files from Previous Projects & Post Project Analysis

Once one project has been planned and scheduled using a computer based project management system, a draft scope of work, suggested sequencing and set of durations exists for use on the next project. (We restrict our attention here to single building projects.) How should this experience be processed and stored so that it is readily accessible for future projects and what operators are required to upgrade and manipulate it for use on a particular project?

4.3.1.1 Approach 1

We suggest that three representations of past experience could be used, two of which are important to the objectives here. The first and least useful representation is the actual project files with no processing. In this format, their value is restricted to administrative matters associated with the project itself, such as the pursuit of claims. Such files could be archived for future reference. We note that over time, a large number of such archived files will exist, and their long term value is questionable.

4.3.1.2 Approach 2

Of greater value is the generation of a data base of past projects, after some post project analysis has been performed. For this case, the only information retained would pertain to scoping, sequencing and durations (activity list, precedence relationships and activity durations), along with specific context information such as project size, team members and market conditions (see item 4.3.3 below). Further, this information would represent a merging of as-planned and as-built files to account for lessons gained over the duration of the project and to exclude adjustments made in response to special conditions associated with the project.

Use of this approach would require the development of a post project processor, a data base of project files along with a directory, and a set of operators to allow file copying and editing.

The post project analyzer would assist in the merging of as-planned and as-built files and the assignment of standard code numbers to reflect normal work packaging practices and location designations, and would flag any unusual activities, sequences or durations. This analysis process would involve the adoption of standards in terms of activity descriptions and coding. As well, standards would have to be developed over time for production rates as a function of project size and design features. A basic premise of this approach is that complete scoping of the project would be performed at its start and that a baseline schedule would be archived for post project analysis. This archived file would be the one subject to modification based on actual project performance (i.e. incorporation of incremental learning). It would then be archived with the project name entered on a directory of past projects. Then, when a new project has to be planned and scheduled, the user would scan the directory and check context information associated with each archived project until a project similar to the new one is identified. In fact, this process could be automated, with the system identifying the most relevant previous project. A copy of this file would then be made, providing a quick start for the new project. While this approach is workable, the number of archived project files could become unwieldy.

4.3.1.3 Approach 3

The third approach is similar to the second, with the main difference being that instead of maintaining separate files on previous projects, past experience would be incorporated on an incremental basis into less than a handful of project files, each of which represents a particular type of high-rise residential building - e.g. single suite per floor; rental tower; rental slab; luxury condominium tower; and luxury condominium slab. Determination of the specific features that should be used to distinguish one project type from another is left for future work.

The process of updating archived project files would then proceed as follows. First, the post project analysis of the recently completed project would be made as described above. Once done, a comparison of the processed file with the archived file of similar project type would be made by the computer. Differences in activity scoping, sequencing and durations would be highlighted and the user would have the option to modify the archived file to reflect changes in practice that should be passed on. The updated archived file would then provide a starting point for the next similar type of project. The benefits of this approach are a dynamic experience base and a manageable set of project experience. However, it presumes that significant differences in design details, materials, finishes and systems do not exist.

The archived files could be organized in a variety of ways: by trade, see items 4.3.2 and 4.3.4; or by phase and system, see item 4.3.6. We suggest that a trade grouping would be the most useful because of the added benefit of being able to scope subcontracts quickly and because of the predisposition of project personnel to think in terms of trade packages. Use of the Masterformat standard coding system, at least in part, should also be adopted.

4.3.1.4 File Contents: Approach 3

We examine briefly, by way of example, the information content of the files and the type of explanatory information that should be encoded. Only scoping and sequencing information are treated. We use the drywall trade as an example.

Trade Information:

Use of standard descriptors and responsibility code numbers associated with the masterformat division of work should be used.

Trade: Drywall Responsibility Code: 091

Activity Information:

Treated here are activity numbers, descriptions, activity types and logic information.

An activity code of the form xxx yyy ww zz is used to reflect responsibility code, activity number, subnetwork or building number and activity type (see items 4.3.5 and 4.3.6).

Activity Number and Description

091 101 01 RO	Layout Studding
091 102 01 RC	Exterior Studding
091 103 01 RC	Interior Studding
091 201 01 RC	Exterior Boarding
091 202 01 RC	Interior Boarding
091 203 01 RC	Tape and Fill

Logic Information:

Logic information is described in terms of essential predecessors, preferred predecessors, predecessor type and lag values. By standardizing the coding system, predecessor activities can be referred to by their code numbers.

Activity No.	Essential Predecessors	Preferred Predecessors
091 101 01 RO	151 401 01 RO FS 0 151 402 01 RO FS 0	111 101 01 RO FS 0
091 102 01 RC	031 301 01 RO FS 10	
091 103 01 RC	031 301 01 RO FS 10	091 102 01 RC FS 0
091 201 01 RC	148 001 01 NR FS 0 061 001 01 RO FS 0	
091 202 01 RC	051 001 01 RO FS 071 200 01 RO FS 0 151 301 01 RO FS 0 151 402 01 RO FS 0 151 403 01 RO FS 0	
091 203 01 RC	091 202 01 RC FS 0	

Explanation Module - Knowledge Base:

The user may wish to query the system as to why an activity has been included and/or the basis for its predecessors and the type of predecessor relationships. Examples of responses are given below.

091 101 01 RO Layout Studding

Layout is required first to ensure that mechanical risers are located within interior walls and to ensure positioning of exterior studs yields plumb walls. Layout starts with a typical floor. It is followed by fastening of floor and ceiling tracks and then vertical studs.

Layout work is not required to be continuous. It can be performed by members of the studding crew.

Essential predecessors are mechanical supply and waste water risers. The preferred predecessor is garbage chutes.

091 102 01 RC Exterior studding

It is preferable to break studding into interior and exterior because it is desirable to enclose the structure as quickly as possible. It should lag behind structural work as closely as possible. Work should proceed continuously.

4.3.2 Master Workbreakdowns

Another approach to developing an activity list for a project is to select activities from a master list which purports to be all inclusive. Then, the activities for a specific project constitute a subset of this list.

The elements of this approach include the following:

1) a data base of master lists for different project types (buildings, bridges, etc.);
2) operators to allow editing of each master list (i.e the lists can be built up by the user);
3) operators to allow selection of items on this list which are applicable to the project at hand.

These operators may be used directly by the user (he scans the list and selects appropriate elements) or they may be used by the system itself to select activities through rules which process project context information. Activities selected by either method would be entered into the project file. The operators should allow duplication of these activities for multi-building projects.

For building projects, the most commonly used and accepted list comes from the Masterformat (20) classification of work. This list is presented in figure 4.1. Its use as a starting point has several advantages.

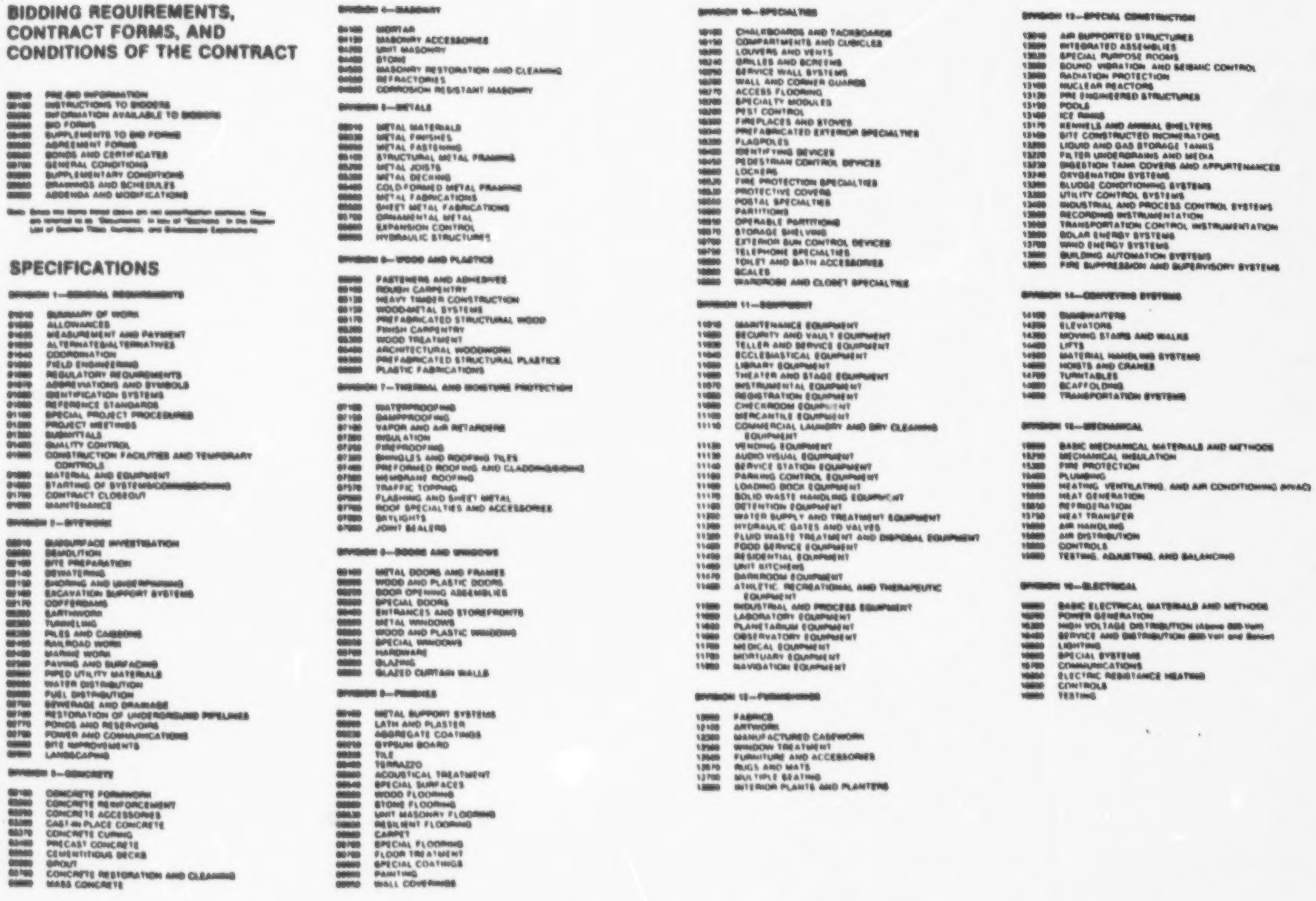
1) The classification of work in terms of divisions, coding and descriptions is widely accepted and provides the basis for most building specification documents.
2) It is virtually all-inclusive.
3) It is hierarchically structured (basically 3 levels with some extension to a fourth), allowing up and down aggregation and disaggregation of work breakdowns.
4) It provides explanatory material and cross-referencing of work (broadscope information - see figure 4.2). This information constitutes an important start on the knowledge base for an expert system for scoping, sequencing and work packaging.

There are disadvantages though, and they include the following:

1) The masterformat list is a mix of activities, material classifications, physical systems, trade packages, construction methods and individual components.
2) Trade packages may consist of items drawn from more than one division, and hence an activity coding system cannot be identical to the Masterformat coding, necessitating use of a dual coding system depending on how company records are maintained.
3) The three level list contains in excess of 1000 items to scan through, making it unwieldy to use on a day-to-day basis.

However, this list could be reduced substantially if it were filtered through a specific project type such as high-rise housing.

Implementation of the masterformat list would require the following steps. First, the list would have to be filtered to remove work classifications that are not relevant to housing (e.g. many of the items in divisions 11 and 13). Second, a set of rules would have to be developed to allow combination of work items to form project level activities. Third, a fourth level in the hierarchy would have to be added for many items in the masterformat list in order to create a one-to-one relationship with project level activities.



BIDDING REQUIREMENTS, CONTRACT FORMS, AND CONDITIONS OF THE CONTRACT

00010 PRE-BID INFORMATION
00100 INSTRUCTIONS TO BIDDERS
00200 INFORMATION AVAILABLE TO BIDDERS
00300 BID FORMS
00400 SUPPLEMENTS TO BID FORMS
00500 AGREEMENT FORMS
00600 BONDS AND CERTIFICATES
00700 GENERAL CONDITIONS
00800 SUPPLEMENTARY CONDITIONS
00850 DRAWINGS AND SCHEDULES
00900 ADDENDA AND MODIFICATIONS

Note: Since the items listed above are not specification sections, they are referred to as "Documents" in lieu of "Sections" in the Master List of Section Titles, Numbers, and Broadscope Explanations.

SPECIFICATIONS

DIVISION 1—GENERAL REQUIREMENTS

01010 SUMMARY OF WORK
01020 ALLOWANCES
01025 MEASUREMENT AND PAYMENT
01030 ALTERNATES/ALTERNATIVES
01040 COORDINATION
01050 FIELD ENGINEERING
01060 REGULATORY REQUIREMENTS
01070 ABBREVIATIONS AND SYMBOLS
01080 IDENTIFICATION SYSTEMS
01090 REFERENCE STANDARDS
01100 SPECIAL PROJECT PROCEDURES
01200 PROJECT MEETINGS
01300 SUBMITTALS
01400 QUALITY CONTROL
01500 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS
01600 MATERIAL AND EQUIPMENT
01650 STARTING OF SYSTEMS/COMMISSIONING
01700 CONTRACT CLOSEOUT
01800 MAINTENANCE

DIVISION 2—SITEWORK

02010 SUBSURFACE INVESTIGATION
02050 DEMOLITION
02100 SITE PREPARATION
02140 DEWATERING
02150 SHORING AND UNDERPINNING
02160 EXCAVATION SUPPORT SYSTEMS
02170 COFFERDAMS
02200 EARTHWORK
02300 TUNNELING
02350 PILES AND CAISSONS
02450 RAILROAD WORK
02480 MARINE WORK
02500 PAVING AND SURFACING
02600 PIPED UTILITY MATERIALS
02660 WATER DISTRIBUTION
02680 FUEL DISTRIBUTION
02700 SEWERAGE AND DRAINAGE
02760 RESTORATION OF UNDERGROUND PIPELINES
02770 PONDS AND RESERVOIRS
02780 POWER AND COMMUNICATIONS
02800 SITE IMPROVEMENTS
02900 LANDSCAPING

DIVISION 3—CONCRETE

03100 CONCRETE FORMWORK
03200 CONCRETE REINFORCEMENT
03250 CONCRETE ACCESSORIES
03300 CAST-IN-PLACE CONCRETE
03370 CONCRETE CURING
03400 PRECAST CONCRETE
03500 CEMENTITIOUS DECKS
03600 GROUT
03700 CONCRETE RESTORATION AND CLEANING
03800 MASS CONCRETE

DIVISION 4—MASONRY

04100 MORTAR
04150 MASONRY ACCESSORIES
04200 UNIT MASONRY
04400 STONE
04500 MASONRY RESTORATION AND CLEANING
04550 REFRACTORIES
04600 CORROSION RESISTANT MASONRY

DIVISION 5—METALS

05010 METAL MATERIALS
05030 METAL FINISHES
05050 METAL FASTENING
05100 STRUCTURAL METAL FRAMING
05200 METAL JOISTS
05300 METAL DECKING
05400 COLD-FORMED METAL FRAMING
05500 METAL FABRICATIONS
05580 SHEET METAL FABRICATIONS
05700 ORNAMENTAL METAL
05800 EXPANSION CONTROL
05900 HYDRAULIC STRUCTURES

DIVISION 6—WOOD AND PLASTICS

06050 FASTENERS AND ADHESIVES
06100 ROUGH CARPENTRY
06130 HEAVY TIMBER CONSTRUCTION
06150 WOOD-METAL SYSTEMS
06170 PREFABRICATED STRUCTURAL WOOD
06200 FINISH CARPENTRY
06300 WOOD TREATMENT
06400 ARCHITECTURAL WOODWORK
06500 PREFABRICATED STRUCTURAL PLASTICS
06600 PLASTIC FABRICATIONS

DIVISION 7—THERMAL AND MOISTURE PROTECTION

07100 WATERPROOFING
07150 DAMPPROOFING
07190 VAPOR AND AIR RETARDERS
07200 INSULATION
07250 FIREPROOFING
07300 SHINGLES AND ROOFING TILES
07400 PREFORMED ROOFING AND CLADDING/SIDING
07500 MEMBRANE ROOFING
07570 TRAFFIC TOPPING
07600 FLASHING AND SHEET METAL
07700 ROOF SPECIALTIES AND ACCESSORIES
07800 SKYLIGHTS
07900 JOINT SEALERS

DIVISION 8—DOORS AND WINDOWS

08100 METAL DOORS AND FRAMES
08200 WOOD AND PLASTIC DOORS
08250 DOOR OPENING ASSEMBLIES
08300 SPECIAL DOORS
08400 ENTRANCES AND STOREFRONTS
08500 METAL WINDOWS
08600 WOOD AND PLASTIC WINDOWS
08650 SPECIAL WINDOWS
08700 HARDWARE
08800 GLAZING
08900 GLAZED CURTAIN WALLS

DIVISION 9—FINISHES

09100 METAL SUPPORT SYSTEMS
09200 LATH AND PLASTER
09230 AGGREGATE COATINGS
09250 GYPSUM BOARD
09300 TILE
09400 TERRAZZO
09500 ACOUSTICAL TREATMENT
09540 SPECIAL SURFACES
09550 WOOD FLOORING
09600 STONE FLOORING
09630 UNIT MASONRY FLOORING
09650 RESILIENT FLOORING
09680 CARPET
09700 SPECIAL FLOORING
09780 FLOOR TREATMENT
09800 SPECIAL COATINGS
09900 PAINTING
09950 WALL COVERINGS

DIVISION 10—SPECIALTIES

10100 CHALKBOARDS AND TACKBOARDS
10150 COMPARTMENTS AND CUBICLES
10200 LOUVERS AND VENTS
10240 GRILLES AND SCREENS
10250 SERVICE WALL SYSTEMS
10260 WALL AND CORNER GUARDS
10270 ACCESS FLOORING
10280 SPECIALTY MODULES
10290 PEST CONTROL
10300 FIREPLACES AND STOVES
10340 PREFABRICATED EXTERIOR SPECIALTIES
10350 FLAGPOLES
10400 IDENTIFYING DEVICES
10450 PEDESTRIAN CONTROL DEVICES
10500 LOCKERS
10520 FIRE PROTECTION SPECIALTIES
10530 PROTECTIVE COVERS
10550 POSTAL SPECIALTIES
10600 PARTITIONS
10650 OPERABLE PARTITIONS
10670 STORAGE SHELVING
10700 EXTERIOR SUN CONTROL DEVICES
10750 TELEPHONE SPECIALTIES
10800 TOILET AND BATH ACCESSORIES
10880 SCALES
10900 WARDROBE AND CLOSET SPECIALTIES

DIVISION 11—EQUIPMENT

11010 MAINTENANCE EQUIPMENT
11020 SECURITY AND VAULT EQUIPMENT
11030 TELLER AND SERVICE EQUIPMENT
11040 ECCLESIASTICAL EQUIPMENT
11050 LIBRARY EQUIPMENT
11060 THEATER AND STAGE EQUIPMENT
11070 INSTRUMENTAL EQUIPMENT
11080 REGISTRATION EQUIPMENT
11090 CHECKROOM EQUIPMENT
11100 MERCANTILE EQUIPMENT
11110 COMMERCIAL LAUNDRY AND DRY CLEANING EQUIPMENT
11120 VENDING EQUIPMENT
11130 AUDIO-VISUAL EQUIPMENT
11140 SERVICE STATION EQUIPMENT
11150 PARKING CONTROL EQUIPMENT
11160 LOADING DOCK EQUIPMENT
11170 SOLID WASTE HANDLING EQUIPMENT
11190 DETENTION EQUIPMENT
11200 WATER SUPPLY AND TREATMENT EQUIPMENT
11280 HYDRAULIC GATES AND VALVES
11300 FLUID WASTE TREATMENT AND DISPOSAL EQUIPMENT
11400 FOOD SERVICE EQUIPMENT
11450 RESIDENTIAL EQUIPMENT
11460 UNIT KITCHENS
11470 DARKROOM EQUIPMENT
11480 ATHLETIC, RECREATIONAL AND THERAPEUTIC EQUIPMENT
11500 INDUSTRIAL AND PROCESS EQUIPMENT
11600 LABORATORY EQUIPMENT
11650 PLANETARIUM EQUIPMENT
11660 OBSERVATORY EQUIPMENT
11700 MEDICAL EQUIPMENT
11780 MORTUARY EQUIPMENT
11850 NAVIGATION EQUIPMENT

DIVISION 12—FURNISHINGS

12050 FABRICS
12100 ARTWORK
12300 MANUFACTURED CASEWORK
12500 WINDOW TREATMENT
12600 FURNITURE AND ACCESSORIES
12670 RUGS AND MATS
12700 MULTIPLE SEATING
12800 INTERIOR PLANTS AND PLANTERS

DIVISION 13—SPECIAL CONSTRUCTION

13010 AIR SUPPORTED STRUCTURES
13020 INTEGRATED ASSEMBLIES
13030 SPECIAL PURPOSE ROOMS
13080 SOUND, VIBRATION, AND SEISMIC CONTROL
13090 RADIATION PROTECTION
13100 NUCLEAR REACTORS
13120 PRE-ENGINEERED STRUCTURES
13150 POOLS
13160 ICE RINKS
13170 KENNELS AND ANIMAL SHELTERS
13180 SITE CONSTRUCTED INCINERATORS
13200 LIQUID AND GAS STORAGE TANKS
13220 FILTER UNDERDRAINS AND MEDIA
13230 DIGESTION TANK COVERS AND APPURTENANCES
13240 OXYGENATION SYSTEMS
13260 SLUDGE CONDITIONING SYSTEMS
13300 UTILITY CONTROL SYSTEMS
13400 INDUSTRIAL AND PROCESS CONTROL SYSTEMS
13500 RECORDING INSTRUMENTATION
13550 TRANSPORTATION CONTROL INSTRUMENTATION
13600 SOLAR ENERGY SYSTEMS
13700 WIND ENERGY SYSTEMS
13800 BUILDING AUTOMATION SYSTEMS
13900 FIRE SUPPRESSION AND SUPERVISORY SYSTEMS

DIVISION 14—CONVEYING SYSTEMS

14100 DUMBWAITERS
14200 ELEVATORS
14300 MOVING STAIRS AND WALKS
14400 LIFTS
14500 MATERIAL HANDLING SYSTEMS
14600 HOISTS AND CRANES
14700 TURNTABLES
14800 SCAFFOLDING
14900 TRANSPORTATION SYSTEMS

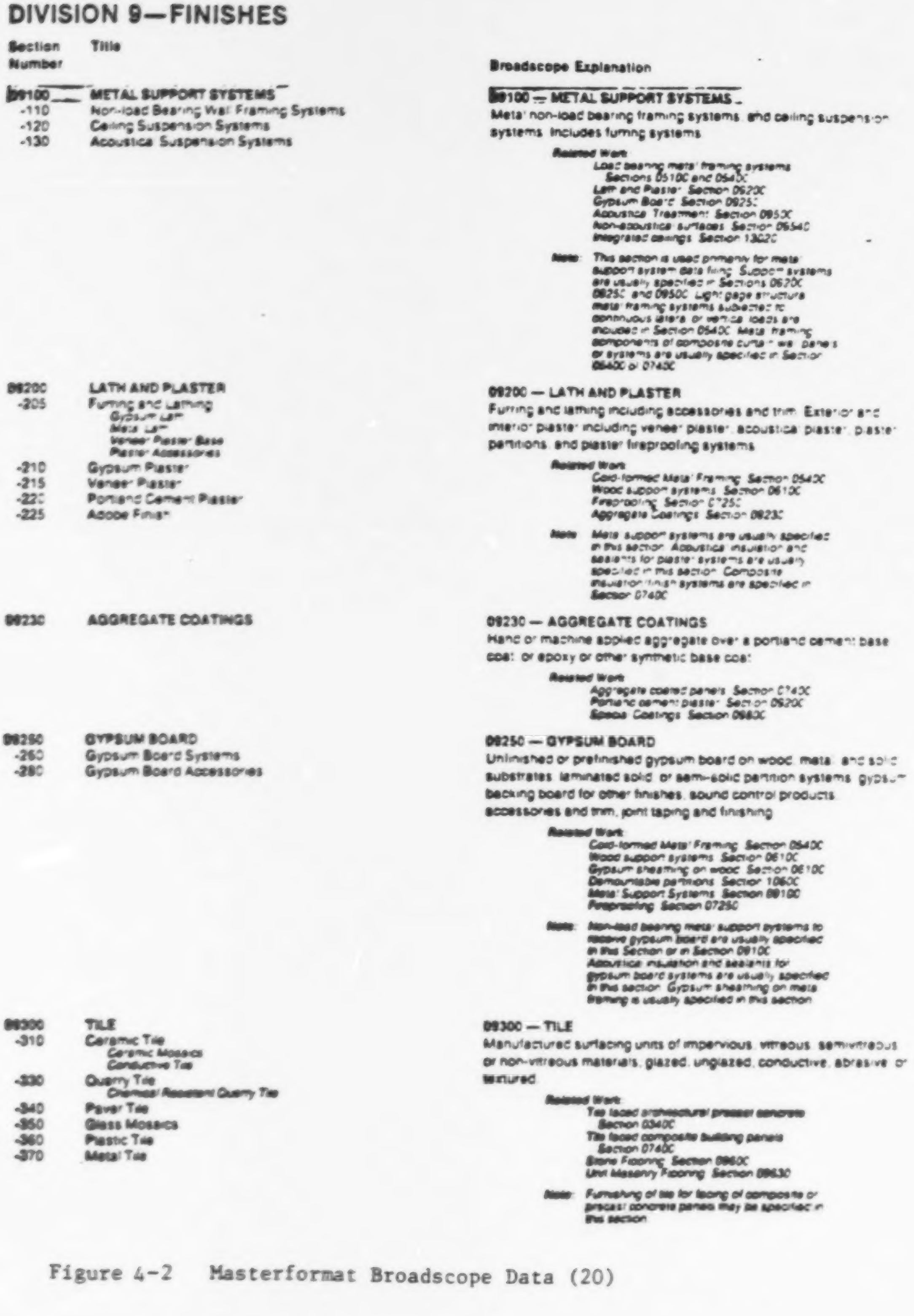
DIVISION 15—MECHANICAL

15050 BASIC MECHANICAL MATERIALS AND METHODS
15250 MECHANICAL INSULATION
15300 FIRE PROTECTION
15400 PLUMBING
15500 HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)
15550 HEAT GENERATION
15650 REFRIGERATION
15750 HEAT TRANSFER
15850 AIR HANDLING
15880 AIR DISTRIBUTION
15950 CONTROLS
15990 TESTING, ADJUSTING, AND BALANCING

DIVISION 16—ELECTRICAL

16050 BASIC ELECTRICAL MATERIALS AND METHODS
16200 POWER GENERATION
16300 HIGH VOLTAGE DISTRIBUTION (Above 600-Volt)
16400 SERVICE AND DISTRIBUTION (600-Volt and Below)
16500 LIGHTING
16600 SPECIAL SYSTEMS
16700 COMMUNICATIONS
16850 ELECTRIC RESISTANCE HEATING
16900 CONTROLS
16950 TESTING

Figure 4-1 Masterformat Classification (20)



DIVISION 9—FINISHES

Section Number	Title
09100	**METAL SUPPORT SYSTEMS**
-110	Non-load Bearing Wall Framing Systems
-120	Ceiling Suspension Systems
-130	Acoustical Suspension Systems
09200	**LATH AND PLASTER**
-205	Furring and Lathing
	Gypsum Lath
	Metal Lath
	Veneer Plaster Base
	Plaster Accessories
-210	Gypsum Plaster
-215	Veneer Plaster
-220	Portland Cement Plaster
-225	Adobe Finish
09230	**AGGREGATE COATINGS**
09250	**GYPSUM BOARD**
-260	Gypsum Board Systems
-280	Gypsum Board Accessories
09300	**TILE**
-310	Ceramic Tile
	Ceramic Mosaics
	Conductive Tile
-330	Quarry Tile
	Chemical Resistant Quarry Tile
-340	Paver Tile
-350	Glass Mosaics
-360	Plastic Tile
-370	Metal Tile

Broadscope Explanation

09100 — METAL SUPPORT SYSTEMS

Metal non-load bearing framing systems, and ceiling suspension systems. Includes furring systems.

Related Work:
Load bearing metal framing systems
Sections 05100 and 05400
Lath and Plaster: Section 09200
Gypsum Board: Section 09250
Acoustical Treatment: Section 09500
Non-acoustical surfaces: Section 09540
Integrated ceilings: Section 13020

Note: *This section is used primarily for metal support system data filing. Support systems are usually specified in Sections 09200, 09250, and 09500. Light gage structural metal framing systems subjected to continuous lateral or vertical loads are included in Section 05400. Metal framing components of composite curtain wall panels or systems are usually specified in Section 05400 or 07400.*

09200 — LATH AND PLASTER

Furring and lathing including accessories and trim. Exterior and interior plaster including veneer plaster, acoustical plaster, plaster partitions, and plaster fireproofing systems.

Related Work:
Cold-formed Metal Framing: Section 05400
Wood support systems: Section 06100
Fireproofing: Section 07250
Aggregate Coatings: Section 09230

Note: *Metal support systems are usually specified in this section. Acoustical insulation and sealants for plaster systems are usually specified in this section. Composite insulation/finish systems are specified in Section 07400.*

09230 — AGGREGATE COATINGS

Hand or machine applied aggregate over a portland cement base coat, or epoxy or other synthetic base coat.

Related Work:
Aggregate coated panels: Section 07400
Portland cement plaster: Section 09200
Special Coatings: Section 09800

09250 — GYPSUM BOARD

Unfinished or prefinished gypsum board on wood, metal, and solid substrates; laminated solid, or semi-solid partition systems; gypsum backing board for other finishes, sound control products, accessories and trim, joint taping and finishing.

Related Work:
Cold-formed Metal Framing: Section 05400
Wood support systems: Section 06100
Gypsum sheathing on wood: Section 06100
Demountable partitions: Section 10600
Metal Support Systems: Section 09100
Fireproofing: Section 07250

Note: *Non-load bearing metal support systems to receive gypsum board are usually specified in this Section or in Section 09100. Acoustical insulation and sealants for gypsum board systems are usually specified in this section. Gypsum sheathing on metal framing is usually specified in this section.*

09300 — TILE

Manufactured surfacing units of impervious, vitreous, semivitreous or non-vitreous materials, glazed, unglazed, conductive, abrasive or textured.

Related Work:
Tile faced architectural precast concrete
Section 03400
Tile faced composite building panels
Section 07400
Stone Flooring: Section 09600
Unit Masonry Flooring: Section 09630

Note: *Furnishing of tile for facing of composite or precast concrete panels may be specified in this section.*

Figure 4-2 Masterformat Broadscope Data (20)

As illustrated below, activities can appear at the second, third or fourth level in the hierarchy and single or multiple activities can result from one work classification. It is even possible that a single activity can reflect multiple Masterformat work classifications.

An example of a second level activity and a one-to-one relationship is as follows.

Level 1 Division 02 Sitework
Level 2 02050 Demolition.....activity level

The activity would be 021 050 01 NR - Demolish Existing Structures.

An example of a third level activity and a many-to-one relationship is as follows.

Level 1 Division 08 Doors and Windows
Level 2 08300 Special Doors
Level 3 08310 Sliding Doors......activity level

Level 1 Division 08 Doors and Windows
Level 2 08500 Metal Windows
Level 3 08520 Aluminum Windows...activity level

The activity would be 081 520 RO Install Aluminum Windows and Doors.

An example of a fourth level activity and a one-to-many relationship is as follows.

Level 1 Division 03 Concrete
Level 2 03100 Concrete Formwork
Level 3 03110 Structural Cast-in-place Concrete Formwork
Level 4 Activities
031 111 RO Form Basement Walls & Columns
031 112 RO Form Basement Floor Slabs
031 113 RO Form Main Floor Slab
031 114 RO Form Typical Floor Walls & Columns
031 115 RO Form Typical Floor Slab

The formulation and use of automated rules to determine the level at which an activity should be specified and whether it constitutes a one-to-one, one-to-many or many-to-one (including more than one division) is a very complex task, particularly as it is also a function of building context information,as well.

At this juncture, it is suggested that the Masterformat is best used as follows. First, it provides a very good basis for developing a standardized coding system which also helps to integrate other management functions. Second, it provides an excellent checklist for developing a comprehensive list of activities for various sub-classifications of housing projects as described in section 4.3.1. Third, the existing three level hierarchy should be built into a project management system to serve two functions: (i) to act as a mnemonic device when the user wants to check manually the project definition for completeness; and (ii) to provide the basis for automated completeness checks on project scoping as a function of project context.

4.3.3 Project Context Information

Building context is the major determinant of a project plan and schedule. It describes the major design features (e.g. concrete flat plate structure, masonry cladding system, luxury finishes, etc.), physical dimensions and quantities, economic and contractual environment, site conditions, etc., which define the project and make it unique.

The challenge here is to find the minimal information specification for the project that is essential for accurate scoping and sequencing of project activities. Unless an input data item occurs in one or more rules, it should be excluded. Requests for too much information will lead to failure as users are loathe to spend time inputting descriptive data. Eventually, integration of computer aided design and estimating routines with project management systems will provide much of this information automatically.

Here we examine classifications of context information, its standardization and the uses that can be made of it for scoping and sequencing activities. Where appropriate, we describe these uses by citing examples of rules which directly affect activity definition, sequencing and duration estimation, or which generate requests for additional information which in turn is used for these tasks. We employ the organizational schema of phases and systems and subnets (items 4.3.6 and 4.3.7) to help classify context information. We leave unresolved the practical issue of whether or not context information should be input in entirety at the start of defining a new project, or bit by bit as different phases of the project are treated. Our preference is for the former, although some users tend to favour an incremental definition approach.

Context information can be usefully structured under the following headings:

1) Information that helps define the overall project and which may lead to requests for additional user supplied information; and
2) Information that influences one system or activity.

In what follows, we provide examples of the data elements that should be treated under each heading. Development of a complete set of elements is left for future work. To facilitate standardization of information and simplicity of data entry, we suggest the use of input screens with predetermined choices for variable values.

4.3.3.1 Context Information for Overall Project Definition

Several information groupings under this heading are viewed to be significant for scoping activities. They are: (a) Project Type; (b) Project Size; (c) Project Team; (d) Project Time Frame; (e) Contract Type and Provisions; (f) Market Conditions; and (g) Site Conditions.

(a) Project Type

Under this heading we treat issues of quality and use. The accompanying rules help identify the kinds of finishes and accessories required which in turn impact on the need for procurement sequences and their duration, the number of trades and the number and sequencing of finishing activities.

Examples of the type of information that could be sought along with rules that make use of them are presented in Figure 4 -3.

Data Element	Data Element Value			
User Income	Low	Middle	High	Very High
Ownership	Rental	Condominium		
User Type	Singles	Couples	Families	Retirees
Show Suites	Yes	No		

Rules
IF user income <VERY HIGH>, THEN Division 9 finishes correspond to class <LUXURY>
IF finish class <LUXURY>, THEN request input from user on finishing schedule and sourcing of finishes.
IF user type <RETIREES>, THEN add activities for special amenities (HANDRAILS, LIFE SUPPORT, etc.)
IF show suite <YES>, THEN insert subnetwork <SHOW SUITE>.

Figure 4 - 3 Project Type Information and Rules

(b)Project Size

Here we treat issues dealing with number of buildings, sharing of common project elements such as underground parking, size of each building in terms of number of floors in substructure, number of floors in superstructure, floor plate size, number of parking units, and number of suites per typical floor. This information can be used to help determine location ranges for repetitive activities, the activity coding system when multiple buildings are involved, whether or not certain activity cycles need to be subdivided, lag relationships between activities, etc.

Information that should be sought is listed in Figure 4 - 4 along with example rules.

Data Element		Data Element Value
Number of Buildings		Enter number _
Building size		{Number of floors _
		{Square Feet/floor _
	Enter for each bldg	{Plan Shape - Tower Rectangle Y
		{Suites per typical floor _
Number of Basements		Enter Number _
Number of parking units		Enter Number _

Rules

IF number of buildings >1,THEN ask if parking levels shared.

IF number of buildings >1, THEN increment building number code by one each time next building added to activity list.

ASSIGN to each repetitive finishing activity a location range from MN to PH.

IF square feet/floor greater than <12000>,THEN ask if floor will be formed and poured in sections.

IF floor will be poured in sections, THEN duplicate activities in subnet <STRUCTURE> <n> times.

IF number of suites per floor equals <1>, THEN lag each rough-in and finishing activity by one floor because of congestion problems.

IF number of floors less than <6>,THEN ask if elevators <HYDRAULIC>.

IF elevators <HYDRAULIC>, THEN insert elevator subnet <HYDRAULIC>.

Figure 4 - 4 Project Size Information and Rules

(c) Project Team

Here we treat the attributes of members of the project team, including the client, architect, engineers, subtrades and suppliers. These attributes are used to develop a trade list for the project at hand and to assist in identifying required procurement sequences, their duration and activity durations. An underlying assumption is that a data base exists which contains information on clients, designers, trades, and suppliers with which the firm has had previous experience, see section 4.3.4. Of particular importance is data pertaining to past time performance, both for procurement and field work, quality of supervision and skill levels of tradesmen. This information will be obtained, in part, from the collection and analysis of daily site information as described in the previous chapter.

Initial data requested deals with the firm names of team members. A check is made of each name against entries in the data base. If the name is recognized, then rules are invoked based on the attributes of the firm. The user is then informed of these attributes and their consequences and is given the opportunity to override execution of one or more rules. If the name is not known, then the user is queried for known facts. This information is entered automatically into the database of team members. In the event of no knowledge about a new team member, standard default values would be used in the rules.

Consider the case where the name of the client is known because of previous dealings. Then the following example sequence of rules could be fired depending on the values of client attributes.

> IF <CLIENT> <INDECISIVE> THEN add <CLIENT DECISION> to procurement sequence task list.
>
> IF <CLIENT> <INDECISIVE> THEN add procurement sequence to each <DIVISION 9> activity.

The effect of these rules is that all finishing activities (painting, tiles, carpeting, etc) will have procurement sequences in which the role of the client is specified. Then, when the project is executed, delays attributable to slow decision making or flipflops in decisions by the client can be identified.

Similar types of rules could be used to assign procurement sequences to subtrade activities and to adjust subtrade durations based on known supervision and tradesmen skill levels.

(d) Project Time Frame

Information on contractual provisions dealing with project start, completion and intermediate milestone dates is entered here. It is used in conjunction with heuristic algorithms and information on project size to determine the time frames of major work packages (substructure, superstructure, mechanical, electrical, etc.). Once this approximate timing is known, checks on weather sensitivities can be made, along with checks on feasible production rates, including the potential for multiple crewing. These checks may result in the adjustment of activity durations and/or the addition of activities. Confirmation of the validity of these adjustments is made after preparation of the first draft schedule by rechecking the rules used.

Examples of rules that could be used are as follows.

> IF <SUPERSTRUCTURE> equals <CONCRETE> and <SUPERSTRUCTURE> scheduled during <WINTER>, then extend activity durations by <20%> to account for days lost.
>
> IF <SUPERSTRUCTURE> equals <CONCRETE> and <SUPERSTRUCTURE> scheduled during <WINTER>, THEN decide on <CONCRETE STRATEGY>.
>
> IF <WINTER> temperature is less than zero degrees Celsius, THEN <CONCRETE STRATEGY> is <TARPS & HEATING>.
>
> IF <WINTER> temperature is greater than zero degrees Celsius and less than ten degrees Celsius, THEN <CONCRETE STRATEGY> is <ADMIXTURES>.

(e) Contract Type and Provisions

Lump sum and construction management are the two main contract types encountered in high-rise residential construction. Further, under each type, design and construction may be fast-tracked. Other information of importance from the contract deals with liquidated damages, responsibilities for obtaining key permits and supplying finishes, etc.

Arising from this type of information are rules dealing with whether or not:

1) time contingencies should be built into the schedule;
2) design activities should be included (very important for fast track-construction); and
3) client responsibilities should be included.

Example rules are as follows.

IF project <FAST-TRACKED>, THEN include procurement tasks <PRETENDER, TENDER, POST TENDER> in procurement sequence.

IF project <LUMP SUM> and liquidated damages <YES>, THEN include time contingency in <SUBSTRUCTURE, SUPERSTRUCTURE, DRYWALL, CLEANUP & DEFICIENCY> activities.

(f) Market Conditions

General and specific information describing current and anticipated construction volume or capacity utilization is important for assessing durations for procurement sequences and activities. General information deals with the availability of skilled manpower and construction volume in the local market as well as in the markets served by key suppliers. Specific information deals with the work load of the firm itself and of members of the design team and the subtrades. An inverse relationship exists between capacity utilization and time and quality variables. The worse the economy, the greater the availability of skilled designers and tradesmen, the higher the productivity and the better the quality of work. At the time of writing of this report, the opposite is true, and substantial delays are being experienced due to late and sloppy drawings and lack of skilled manpower. Quantification of this type of information has been tackled in various estimating references (1).

(g) Site Conditions

Under site conditions, issues of weather, storage, access and ground conditions can be treated. Except for weather, direct relationships among durations and sequences with site conditions are difficult to formulate. Recent experience on one high-rise residential project, as described in the analysis of daily site data in the previous chapter has demonstrated the complexity of correlating site conditions with time performance. We are pursuing this topic in a separate research initiative. For now, it is suggested that only month by month weather data in terms of temperature ranges and precipitation levels be captured here. This data is then used along with time frame data to make adjustments to activity durations and additions to the activity list directed at controlling the work environment.

4.3.3.2 Information Specific to One System or Activity

Information specific to one system or activity can be usefully organized by employing the concept of phases and systems which are discussed in sections 4.3.6 and 4.3.7 respectively. Here, we treat the entry of design and construction details and site condition information associated with the main components of the project and their use in identifying relevant activities, sequences and durations. The user would be queried system by system as to the main design features/construction methods/site variables that impact on the planning and scheduling of the system and its linkages with other systems/activities. Two examples are given in Figures 4-5 and 4-6 respectively, to illustrate the type of information to be gathered and its use in the form of rules.

System: CONCRETE SUPERSTRUCTURE

Features: Flat Plate (Y/N)__ Posttensioned (Y/N)__
Floors all similar (Y/N)__

Methods: Slabs fly-formed (Y/N)__ No. of Sets __
Walls/Columns Gang-formed (Y/N)__
Form set for complete floor (Y/N)__
Stairs Precast (Y/N)__
Concrete Placement: Slab - Pump or Bucket
Walls/Cols - Pump or Bucket

IF <SLABS> posttensioned, THEN add (POSTTENSION SLAB> to activity list.

IF <SLAB> fly-formed and number of sets equals <2>,
THEN WEATHER is not a constraint on stripping and cycling forms.

IF <WALL/COLUMN> form set for less than <100%> of floor,
THEN duration of <FORM/POUR WALLS and COLUMNS> is 2 days.

IF <WALLS/COLUMNS> <GANG-FORMED> and <SLAB> <FLY-FORMED>
and <STAIRS> <PRECAST> and <CONCRETE> <PUMPED>
THEN cycle duration for typical floor should be 4 days or less.

Figure 4 - 5 Superstructure Context Information and Rules

System: EXTERIOR ENCLOSURE

Features: Select Wall Type : Outsulation
Brick Masonry
Precast Panels
Curtain Wall

IF <ENCLOSURE> <OUTSULATION>
THEN add activity sequence <RIGID INSULATION & MESH
--> APPLY ACRYLIC SCRATCH COAT --> APPLY ACRYLIC FINISH COAT
--> CAULK OUTSULATION CONTROL JOINTS>.

IF <ENCLOSURE> <OUTSULATION>
THEN add activity <INSTALL SCAFFOLDING>.

Figure 4 - 6 Enclosure Context Information and Rules

4.3.4 Standard List of Clients, Consultants, Subtrades & Suppliers

Information about project team members constitutes important input to the planning and control process. Two types of information are required. First, information that describes how to contact the team members. No operations are required on this information from an expert system perspective. The second type of information, on the other hand, is interpretable by the expert system and affects the selection, sequencing and duration of activities, and the need for procurement sequences and task definition.

The challenge here relates to identifying the main variables required to describe the project participants or team members (e.g. quality of architectural details produced by firm ABC, optimism in duration estimation for elevator firm Richmond, etc.) and development of a data base which contains data describing these variables for designers, subcontractors, suppliers and clients. Values for the data variables would be built up over time given formal post project analyses. This is essential to ensure that objective data values are used. Then, given the selection of a particular team member, rules can be processed which will provide input to the planning and scheduling process regarding likely activity durations and the need for and length of procurement sequences.

A brief discussion of the variables appropriate to each type of team member and example rules are given below.

Client

Concerns about owners as they relate to planning and scheduling deal with the owners knowledge of the construction process, their ability to make a decision in a timely manner and stick with it, what commitments they may have made to external parties (marketing groups, purchasers) and their tolerance for the implications that changes pose both for the design and construction process.

Intelligence on owners can be gleaned from direct past experience with them, from consultants that have worked for them as well as from subcontractors. It can be represented in the form of rules, especially in regard to including the role of the owner in the construction plan. Example rules are cited below.

> IF <CLIENT> not knowledgeable of construction or if <CLIENT> not decisive,
> THEN add client decision activities to <FLOOR FINISHING, WALL FINISHING, LOBBY FINISHING,...... ACTIVITIES>.
>
> IF <CLIENT> knowledgeable but intolerant and <PROJECT FAST-TRACKED>,
> THEN add detailed procurement sequences to key activities to include <DRAWING PREPARATION, CLIENT APPROVAL,>.

Consultant

A number of variables can be used to describe each consultant. Specific variable values can then be used to fire rules which will influence procurement sequences, activities in the plan and durations. Variables of interest deal with the current volume of work of the consultant, the seniority of the design team assigned to the project, prior experience with similar projects, organizational abilities, especially in terms of producing working drawings in a sequence which matches needs in the field, detailing accuracy and quality standards demanded in the field. Example rules are given below.

> IF <ARCHITECT> has heavy work volume, THEN add drawing schedule to project plan and provide to architect.
>
> IF <ARCHITECT> poor on detailing, THEN add extra time for shop drawing preparation and approval procurement tasks.

Subcontractors and Suppliers

Variables of interest here deal with quality of management, quality of tradesmen, current work volume, past performance in terms of timely delivery of materials and equipment, quality control, accuracy of production rate forecasts and requirements for work continuity. Example rules are as follows.

> IF <ABC CO> is DRYWALL subcontractor,
> THEN include <WORK CONTINUITY> as a constraint on <STUDDING & BOARDING>.
>
> IF <DEF CO> is WINDOW supplier and installer,
> THEN add <CONTINGENCY> to procurement task - fabricate and deliver.
>
> IF <GHI CO> is REINFORCING contractor, THEN request <JOE HOTROD> as site foreman.
>
> IF <ABC CO> is DRYWALL subcontractor, and IF <WORK VOLUME> is <HIGH> and if <MARKET> is at capacity, THEN lengthen activity durations by <20%>.

Given variables that describe each type of team participant and a means of quantifying them, the task of developing a data base is straightforward. The user has to be able to update the data base by adding/deleting membership and editing variable values for each member of the data base. The data base has to be accessible directly to the user for editing and production of lists and from the expert system where variable values are interpreted for action and contact attributes assigned to the project file.

Suggested contents of the data base are illustrated in Figure 4-7 below. Standardization of the attributes used for describing each type of team member and the set of permissible values has yet to be established.

CLIENT/CONSULTANT/SUBTRADE DIRECTORY

Attributes	CLIENT MEMBERS
Firm name	C.1 ABC development ltd
Contact person	John Builder
Address	1234 Development Way, Vancouver, B.C. V6P 9S8
Telephone	(604) 123-4567
Fax	(604) 123-6789
Experience	excellent-high rise housing
Decisiveness	good
Response time	slow
Acceptance of impact costs	low
	CONSULTANTS
	ARCHITECTS
Firm name	A.1 Arthur Excellence
Contact Person	Bruno Smart
Address	1234 Enlightened Way Richmond, B.C. V7R 9T3
Telephone	(604) 333-4444
Fax	(604) 333-8888
Experience	Commercial office, institutional
Volume of work	At capacity as of 890201
Quality of dwgs	Good
Quality of details	Good
Quality of specs	Very Good
Delivery of dwgs	Slow
Field inspection	Very particular on finishing
	SUBCONTRACTORS & SUPPLIERS
	091 DRYWALL SUBS
Firm Name	091.1 ABC Drywall Ltd.
Contact Person	John Mud
Address	9102 Main Street Burnaby, B.C. V7R 8C0
Telephone	(604) 222-4621
Fax	(604) 222-4721
Site management	Good
Tradesmen skill levels	Average
Current work volume	At capacity
Procurement	Good
Quality	Layout good, finishing average
Production rate	Over optimistic
Work continuity	Required for studding & boarding

Figure 4 - 7 Directory of Team Members

4.3.5 Coding System

While there are various coding systems which purport to offer the basis for a standard, as of yet, no industry wide standard has been formulated and adopted which serves the needs of all management functions (estimating, planning and scheduling and cost accounting). The Masterformat breakdown offers a good starting point, but it fails to offer a consistent basis for identifying trades and activities (see previous discussion in section 4.3.2). Some of the attributes we require in a coding system include an allowance for standard trade assignment, sufficient capacity to allow each activity associated with each possible system choice to have a unique activity number, and flexibility to permit reassignment of activities to different responsibility codes.

Rather than attempting to meet the needs of all management functions in one coding system, we advocate the use of dual or even multiple codes for each activity. Such an approach would permit mappings of information onto breakdowns most suitable for the different functions. We restrict our attention here to the needs of planning and scheduling.

As suggested in section 4.3.2, a coding system of the form xxx yyy ww zz is a useful one. The variables xxx are used to provide a unique identifier for each trade or responsibility code. Furthermore, it accommodates the numbering scheme used by Masterformat for division of work. The third digit allows for multiple contractors to be assigned to one division - e.g. 151, 152 for the case where there are multiple mechanical contractors which is possible on larger projects.

The variables yyy are used to provide a unique activity number within a given responsibility code. While a case could be made for four digits (i.e. yyyy) to ensure capacity for the largest of projects and the total range of systems and choices for each within a trade, the three digit breakdown is sufficient for high rise work.

The ww component is used to identify subnetwork number. Often, when building up the plan for a project, it is useful to build it in parts, and then test and refine each part. Then, the total project plan can be assembled by merging the subnetworks into one project file and connecting them with appropriate logic. As well, subnetworks can form a useful mechanism for representing construction knowledge.

Finally, the zz component is used to describe the type of planning structure which best models the activity (e.g. repetitive with a continuity requirement - RC, start milestone - MS, etc.).

The above coding system provides sufficient richness to treat most of the situations encountered on real projects, but as well, it provides a useful index for representing construction knowledge for use in an expert system.

4.3.6 Project Phasing and Systems

Typically, construction personnel think of a project in terms of various phases, some of which overlap. In this way, they are able to cope with complexity by decomposing a large problem into more manageable components. For example, high rise projects can be described in terms of the following phases: design/permits; demolition and site preparation; mobilization; excavation and shoring; substructure; superstructure; rough-in; enclosure; finishing; special facilities; sitework; and closeout. Grouping of information by phases cuts across trade boundaries and reflects both time and physical aspects or features of the project.

Within many of the phases, activities can be attached to physical systems. For example, for the rough-in phase, systems dealt with include mechanical, electrical, wall, etc. Each system can in turn be described by a system choice (e.g. type of foundation - mat or piles and caps). The activities required to install a system are then attached to the specific system choice.

Use of a phasing and system description of a project provides a useful framework for encoding knowledge and eliciting context information about the physical attributes of a project from the system user.

We present a simplified illustration of the use of this framework in a two step process. First we look at phasing and some of the systems which describe a phase (figure 4.8). Then in figure 4.9 we examine the activities that describe each system choice for one system in a phase. The challenges in terms of developing the knowledge base consist of identifying the activities and their sequencing associated with each choice and the rules which provide the linking of activities among systems as a function of the system choices made. This latter aspect is the most difficult to treat because of the combinatorial nature of the problem.

A simplified example of such rules is provided in figure 4.10. In this example we have assumed that the user responded to queries about cladding treatment and the response was that a combination of brickwork and outsulation was to be used. Note in the example that we have had to treat linkages with other systems as well as interfacing issues when multiple choices are made for one system.

PHASE	SYSTEM
DESIGN/PERMITS	
DEMOLITION & SITE MOBILIZATION	
EXCAVATION & SHORING	SHORING
	ANCHORAGE
SUBSTRUCTURE	FOUNDATION
	WALLS
	SLABS
	DRAINAGE
SUPERSTRUCTURE	FLOORS
	WALLS/COLUMNS
	STAIRS
	ROOF
	MECH/ELEV PENTHOUSE
ROUGH-IN	BLOCKING/BACKING
	PARTITIONS
	ELEVATORS
	PLUMBING
	VENTILATION
	FIRE PROTECTION
	HEATING
	ELECTRICAL DISTRIBUTION
	SECURITY/CABLEVISION
	TELEPHONE
	VACUUMING
ENCLOSURE	CLADDING
	WINDOW/GLAZING
	BALCONY WALLS/RAILING
	BALCONY FLOORS
	ROOFING
	STOREFRONT
FINISHING	FLOOR
	WALLS
	CEILINGS
	MILLWORK
	ELEVATORS
	PLUMBING
	VENTILATION
	FIRE PROTECTION
	HEATING
	ELECTRICAL FIXTURES
	APPLIANCES
SPECIAL FACILITIES	SECURITY/CABLEVISION
	TELEPHONE
	VACUUMING
	POOL
	SAUNAS
SITEWORK	HARD LANDSCAPING
	SOFT LANDSCAPING
	ENCLOSURE
	DRIVEWAYS/WALKWAYS
CLOSEOUT	

Figure 4 - 8 Phasing and Systems

SYSTEM	CHOICES	ACTIVITIES
CLADDING	OUTSULATION	091 300 01 RO INSTALL SCAFFOLDING
		091 301 01 RO APPLY RIGID INSULATION & MESH
		091 302 01 RO APPLY ACRYLIC SCRATCH COAT
		091 303 01 RO APPLY ACRYLIC FINISH COAT
		091 304 01 RO CAULK CONTROL JOINTS
		091 305 01 RO REMOVE SCAFFOLDING
	BRICK MASONRY	041 300 01 RO INSTALL SCAFFOLDING
		041 301 01 RO INSTALL BUILDING PAPER
		041 302 01 RO INSTALL EXTERIOR BRICK
		041 303 01 RO SEAL/CAULK BRICK JOINTS
		041 304 01 RO REMOVE SCAFFOLDING
	PAINTED CONC	092 310 01 RO INSTALL SCAFFOLDING
		092 311 01 RO GRIND CONCRETE FINISH
		092 312 01 RO PATCH & SACK CONCRETE
		092 313 01 RO PAINT EXTERIOR CONCRETE
		092 314 01 RO REMOVE SCAFFOLDING

Figure 4 - 9 Cladding System Choices & Activities

```
IF <CLADDING> system choice <OUTSULATION> and <BRICK MASONRY>,
THEN ask who is <RESPONSIBLE> for <SCAFFOLDING>.

Is trade 041, Masonry or 091, Outsulation responsible for installation and removal of scaffolding?
091

IF <CLADDING> system choice <OUTSULATION> and <BRICK MASONRY> THEN
 091 300 01 RO INSTALL SCAFFOLDING PRECEDES
 091 201 01 R0 EXTERIOR BOARDING WITH FS=0

AND
 091 201 01 RO EXTERIOR BOARDING PRECEDES
 041 301 01 RO INSTALL BUILDING PAPER WITH FS=0

AND
 041 301 01 RO INSTALL BUILDING PAPER PRECEDES
 041 302 01 RO INSTALL EXTERIOR BRICK WITH FS=0

AND
 041 302 01 RO INSTALL EXTERIOR BRICK PRECEDES
 071 101 01 RO INSTALL WINDOWS/EXT DOORS WITH FS=0

AND
 071 101 01 RO INSTALL WINDOWS/EXT DOORS PRECEDES
 091 301 01 RO APPLY RIGID INSULATION & MESH WITH FS=0

AND
 091 301 01 RO APPLY RIGID INSULATION & MESH PRECEDES
 091 302 01 RO APPLY ACRYLIC SCRATCH COAT WITH FS=0

AND
 091 302 01 RO APPLY ACRYLIC SCRATCH COAT PRECEDES
 091 303 01 RO APPLY ACRYLIC FINISH COAT WITH FS=0

AND
 091 303 01 RO APPLY ACRYLIC FINISH COAT PRECEDES
 091 304 01 RO CAULK CONTROL JOINTS WITH FS=0

 AND
 041 303 01 RO SEAL/CAULK BRICK JOINTS WITH FS=0

AND
 091 304 01 RO CAULK CONTROL JOINTS
 AND
 041 303 01 RO SEAL/CAULK BRICK JOINTS PRECEDE
 091 305 01 RO REMOVE SCAFFOLDING WITH FS=0
```

Figure 4 - 10 Rules for Inserting System Choice Activities Into Network

4.3.7 Subnets

Subnetworks provide a useful mechanism for eliciting knowledge from construction experts. Given a project phase, and specific system choices which reflect common practice, subnetworks can be developed which provide a "chunk" of knowledge which can be manipulated as a block. Then rules can be developed which allow for the deletion and insertion of activities within this subnetwork in order to account for size effects (e.g. multiple substructure levels) and for changes in system choice (e.g. the use of H piling and lagging instead of shotcrete for a shoring system).

An example of such a subnetwork is provided in figure 4.11. In this case, it crosses over three phases, (permits, excavation/shoring and substructure, with emphasis on substructure). It represents a first cut at describing the activities and their sequencing required for substructure construction of the typical 10-14 story class of residential buildings currently being constructed in Vancouver. It was developed in consultation with a group of seasoned superintendents and project managers.

In encoding such subnetworks into a system, the assumptions behind the subnetwork have to be made explicit. For example, for the subnetwork shown, common practice is to pump concrete for its placement in footings. Further, only one underground level is assumed and the size of the slab on grade is such that it is placed in two separate pours. These assumptions and others would have to be checked with the user through several queries and through use of rules based on the context information described in section 4.3.3.

Then, rules in two classes would have to be formulated. The first deals with the modification of activities within the subnetwork to reflect system choices and size factors. The second deals with the merging of one subnetwork with another for a different phase.

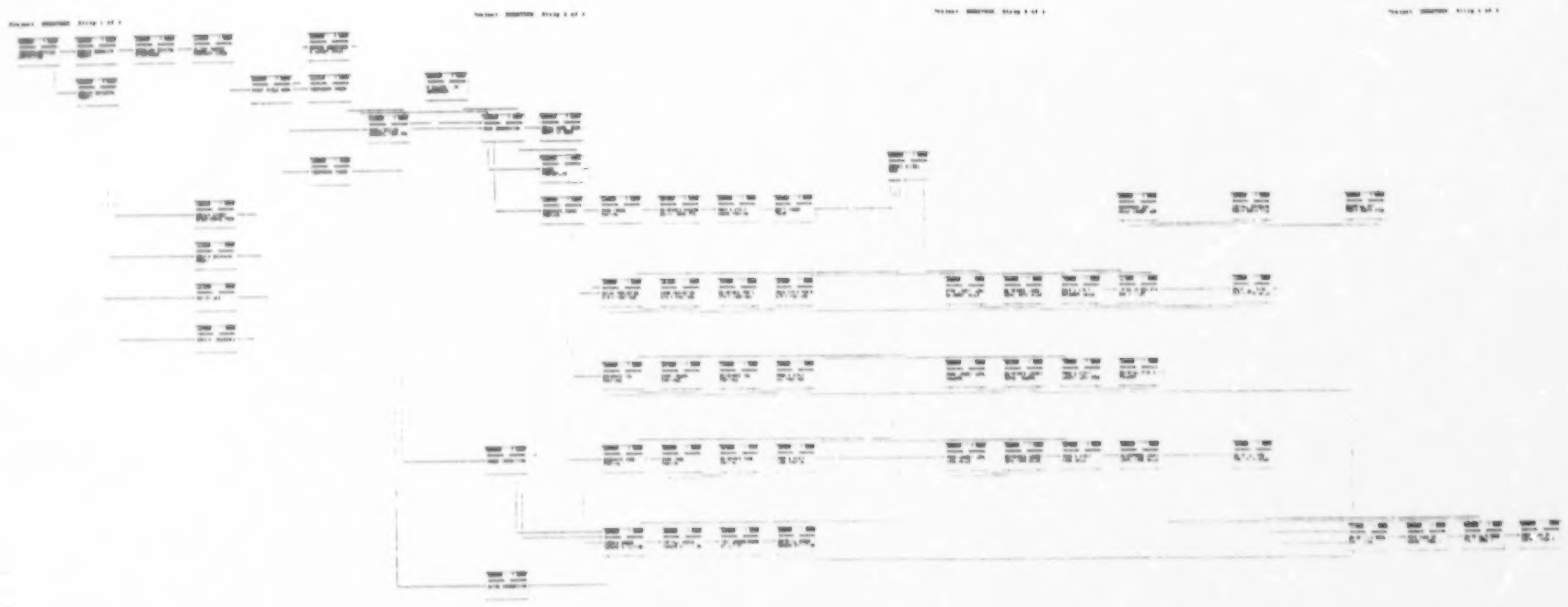


Figure 4-11 Substructure Subnetwork

4.3.8 Series of Knowledge Bases

Discussion in the foregoing sections points the way to decomposition of the total knowledge base into a series of rule bases with can be applied to the various tasks of scoping, sequencing, and determining activity durations within each phase as a function of context information and design features. Other rule bases will deal with the connection of phases and defining the ranges over which activities apply.

Classification of the rules will be required as some can be checked when planning a project (e.g. rules pertaining to scoping and sequencing) while others can only be checked when activities are scheduled in time (rules pertaining to weather effects, crowding, etc.)

4.4 ACTIVITY ATTRIBUTES AND ROLE OF SYSTEM

In this section, we review activity attributes in terms of their representation within an expert system and the role such a system can play in assigning values to them. We build on the activity attribute framework specified in Chapter 3 and pull together the themes presented in the foregoing sections in point form. Attention is limited to activity definition and sequencing.

5.4.1 Activity Description

Uniqueness Attributes:	- Code number in the form of xxx yyy ww zz - Description as a function of system choice or construction phase.
Scope:	- Memo as to operations/components that comprise activity. Used to respond to user queries. - Quantity descriptors.
Mappings:	- Alternative code numbers that can be used for mapping activities into various formats for other functions - estimating, cost accounting.
Knowledge:	- Contains rules regarding replicating activity as a function of project size (e.g. floor slab > 12000 ft**2, form and place in two pours. - Rules regarding subdividing activity into two or more steps to accelerate construction.
Development Tasks:	- Generate comprehensive list of systems, system choices, and activities associated with each system. Requires input from construction personnel. Assign unique code identifier and descriptor to each activity. Assign alternative code numbers and quantity descriptors. Describe scope and document knowledge re subdivision, etc.
Expert System Use:	- Given context information about phase/system/ choice, rules select appropriate activity. - Given context information about project size, rules fired regarding multiplication of activity and assignment of code numbers. - Rules fired so activity inherits attributes related to alternative coding, quantity descriptors, etc.

4.4.2 Responsibility Code for Supply and Install

Uniqueness:

- The responsibility code for an activity may not be unique. Work often gets reassigned among trades. Allowance has to be made for use of standardized descriptions but reassignable responsibilities.
- Depending on contractual conditions, work may be paid for either by supply and install or by install alone. Assign to each activity the normal way progress measured and paid.

Development Tasks:

- Determine trade that is normally responsible for each activity.
- Determine normal way of paying for each activity.

Expert System Use:

- Activity inherits normal responsibility code and basis for payment.

4.4.3 Sequence and Range of Work Locations

Attributes:

- Each activity has a range of work locations that it spans and a preferred ordering of locations.

Development Tasks:

- Determine normal sequence and range of locations as a function of building configuration, temporary storage for materials.
- Determine relationships between location sequences and ranges for activity at hand and sequences/ranges assigned to predecessors.

Expert System Use:

- Rules are fired as a function of building context in order to assign most likely location range and sequence. Allowance made for user to review and alter.
- Rules fired to check sequences as a function of sequence/range assigned to predecessors.

4.4.4 Work Continuity and Multiple Crewing

Attributes:

- Preference as to work continuity for repetitive activities.
- Default number of crews and relationship between crews.

Development Tasks:

- Determine trades/activities for which work continuity is very important.
- Determine feasibility of work continuity as a function of context information re project size (e.g. for buildings with one unit per floor, achieving continuity can be difficult).
- Determine trades/activities for which buffer activities exist, offsetting need for continuity.
- Determine activities for which multiple crewing is meaningful (i.e. simultaneous work at two or more work locations).

Expert System Use:

- Rules dealing with work continuity are fired to assign continuity requirements as a function of trade/activity and project size.
- Rules are fired to suggest which activities can be assigned multiple crews as a function of context information dealing with project time frame.

4.4.5 Activity Durations

Attributes:	- Default duration or production rate as a function of project size. - Modification of default rate as a function of project team characteristics, project time frame and contractual provisions.
Development Tasks:	- For each activity, identify most important quantity descriptor(s) for measuring work. - For each activity, determine normal productivity range and crew size. - Develop basic time estimating relationship for each activity. - Determine adjustment factors for estimating relationship to treat team characteristics, time frame, site conditions, etc.
Expert System Use:	- Activity inherits default production rate if no context information provided. - Rules fired to modify production rate as a function of context information about project type, size, team, time frame, market and site conditions.

4.4.6 Work Methods

Attributes:	- For now, we restrict our attention to the temporary facilities used in executing an activity (e.g. scaffolding, ramp, manhoist, crane, etc.) - Attached to an activity are the facilities it needs.
Development Tasks:	- Identify temporary facilities required as a function of system choice and activity.
Expert System Use:	- Fire rules for the insertion of activities dealing with erection and teardown of temporary facilities, including assign ment of durations.

4.4.7 Activity Predecessors/Successors

Attributes:	- Activity described by essential and preferred predecessors. - Predecessors described in term of predecessor type and lag values. - Predecessor relationships described in terms of location ranges to which they apply. - Successors determined automatically. - Reasoning behind logic as a function of system choices.
Development Tasks:	- For each activity for each system choice, identify predecessor activities as a function of system choices. - Classify predecessors as to essential and preferred. - Determine relationship between predecessor location ranges and location range of activity at hand. - Document predecessor reasoning in form of activity memo for use as explanation facility.

Expert System Use:	- Default predecessors inherited if context information default values used. - Rules fired to modify predecessors and relationships as a function of changes in system choices. - Rules fired to modify predecessor location ranges as function of context information. - User able to query system as to basis for logic assignment.

4.4.8 Procurement Items

Attributes:	- Procurement items that require tracking to ensure timely manufacture/delivery to site.
Development Tasks:	- For each activity of each system choice, determine need to monitor tasks such as sample approvals, shop drawings, fabrication, delivery. If required, attach procurement item to activity. - For context information dealing with project type, team, time frame and market conditions, determine conditions for which procurement items should be attached.
Expert System Use:	- Activity inherits default procurement items. - Rules fired against context information to add/delete procurement items.

4.5 EXPERT SYSTEM COMPONENTS AND USE

We conclude this chapter by providing a description of the components required for an expert system for activity scoping, sequencing and duration estimation and a brief overview of how the system would be used. Our approach builds on the concept of chunking knowledge. That is, we wish to represent and manipulate knowledge in large chunks or blocks and use rules to modify or edit these blocks. This approach provides us with significant processing efficiencies and is the key to being able to treat realistic sized projects. It is made possible by the existence of a robust core of activities that characterize all high rise residential projects.

Our viewpoint is that of the system user as opposed to the knowledge engineer. Hence, we do not concern ourselves with knowledge engineer interface issues which are essential for defining the knowledge base, including encoding standard project files along with context variable default values and entry of rules for modifying the standard project as context variable values are altered.

The main components of our system are as follows.

1) A directory of clients, consultants, subtrades and suppliers. Information included in this directory is described in section 4.3.4 and relates to how to contact team members and their performance capabilities. The user must be able to edit directly this file, including operations of add, delete, change. This directory must also be accessible by the knowledge base through a system controller.

2) A set of standard project files reflecting different types of high rise residential projects (users, size, etc.). Included in this file would be context information (these form the project defaults), an activity list and a set of logic and durations which correspond to the context variable values (sections 4.3.1.4 and 4.3.6). User access to these files would be through the system controller.

3) A context variable template module through which the user interacts with the system. The user specifies context variable values for the project to be planned and scheduled (section 4.3.3). This information is used by the controller to select the most appropriate standard project file and then modify it to reflect the context variable values specified for the project.

4) A system controller that regulates interactions between the user and the components of the system. Its functions include querying the user through the context template if additional information is required, selecting the standard project file which most closely represents the project being modelled, creating a project file for processing by the planning and scheduling system and determining which rules should be fired.

5) A knowledge base which contains a matrix of rules organized by context variable value and activity attribute. This matrix reflects a decomposition of the knowledge base (section 4.3.8) to treat rules classified by the activity attributes of description and code number, logic, continuity and crewing requirements, work location range and sequence, activity duration, procurement tasks and explanation of decisions as a function of context variables describing project type, size, team, time frame, contract type and provisions, market and site conditions and system choices. The controller accesses the appropriate knowledge module as a function of context variable and activity attribute, fires the rules and modifies the project file.

To apply the system, the user would describe the context variable values for the project being treated. These values would be used to select the standard project file which most closely represents the project at hand. The expert system would then create a project file by firing rules in the knowledge base which reflect the context variable values specified. Included in this file would be context variable values, an activity list, activity sequencing and durations, and some explanation to accompany the sequencing and duration decisions. The user would then review this project file and make refinements as required. The advantage of this approach is that the user can focus on exceptions and specialized strategies. The bull work of creating the initial draft schedule is carried out by the system.

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